APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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APPLIED MECHANICS REVIEWS

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THEORY OF THIN-WALLED BARS

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INTRODUCTION. SCOPE OF THE SURVEY

Thin-walled structures, i.e structures composed of sheets and thin-walled profile sections, may be considered highly efficient from the point of view of minimum weight for given strength. Owing to this, they were used, for a long time, in civil and mechanical engineering, as well as in ship-building, as constituents of beams, columns, frameworks, containers, hulls, and so on. But a real development of this type of structure, both in practice and theory, originated in connection with the needs of aviation. Actually, after the Second World War, the theory of thin-walled structures appeared as a new chapter in the textbooks on strength of materials and applied elasticity.

The scope of the present survey is confined to a particular type of thin-walled structure, namely thin-walled bars, which are structural members acted on by axial, bending and twisting loads. This type of structure can be, perhaps, divided roughly into three categories: (a) profile sections, used individually, usually in a form of slender members, (b) composite members, with at least one transverse dimension relatively small compared with the length, such as built-up columns, girders and box beams, (c) shell-shaped structures of rather more dumpy form like airplane fuselages and hulls. We shall treat the first category rather fully and give some attention to the second, since the two have much in common from the standpoint of mechanics of structures. Although the dividing line between classical and nonclassical problems can not always be sharp, we shall concern ourselves mainly with the unorthodox problems arising from the needs of aviation and characteristic of thin-walled bars, rather than with problems applicable to every bar, not necessarily thin-walled, such as those encountered in the theory of flexural buckling of columns or in the theory of frameworks. We shall also make no attempt to refer to the literature involving the theory of unstiffened plates.

In conformity with the usual definition, the model of a thin-walled bar will be assumed to be composed of a thin shell and a system of transverse and longitudinal stiffeners. We take for granted that the transverse stiffeners (ribs) form a system of closely spaced diaphragms, rigid in their own planes, but offering no resistance to the longitudinal displacements of the bar. In some cases of thicker skins, as in rolled profile sections, the stiffening members may not exist; in other cases, they may closely cooperate with the skin, say, in the form of stringers or booms. An introduction of the deformability of the contours makes the analysis highly complicated, and, so far, no sufficiently general method of solution of the problem has been found. For the rather slender bars under consideration, deformability is not of primary importance, yet in some instances, for example in the presence of high sweepback, it can not be neglected (1). Thickness of the wall, small compared with transverse dimensions and much smaller compared with the length of the bar, brings about, in general, failure of the standard methods of computing the induced stress in thin-walled bars. Moreover, a thin-walled bar is particularly sensitive to different kinds of primary and local instability, as well as, in some instances, to a kinematic stress-free distortion (15c). These, and similar phenomena led, during the past three decades, to much research work involving the behavior of thin-walled bars. This research concerns, mainly, axial constraint and diffusion, arbitrary loading, arbitrary form and variation of the cross section in the longitudinal direction, openings, taper, sweepback, stability and vibration. For some of these problems fairly general and rigorous solutions have been found, for others this is not the case because of the difficulties involved. On the other hand, some questions have been elucidated rather late, because over-simplifications, in the older paper, obscured the nature of the phenomena.

The assumption of indeformability of the contour basically differentiates the thin-walled bar problem from that of true shells for which a deformation, caused by a local load, appears to be essential. An attempt has been made by Rabotnov (3) to confirm the distribution of the normal torsion-bending stress in open sections on the basis of a simplified theory of shells. Yet the assumptions of rigid diaphragms and of zero shear strain of the middle surface could not be justified. A qualitative analysis of the integrals of the equations of shells given by Goldenveizer (4), however, proved the validity of the distribution mentioned if some conditions concerning the dimensions of the bar and the variation of load are satisfied. The result of (4) presents a particular case of a general analysis given recently, 1957, for elastic and elastic-plastic open sections by Huan-Ke-Chshi (2), using a method of comparing the orders of the quantities involved.

Apart from the case of Saint-Venant torsion of open sections and a few other cases (such as bending of the walls due to nonlinear rate of twist (5a)), a membrane state of stress in the skin of the thin-walled bars has been adopted generally. From the point of view of three-dimensional analysis of torsion this approximation has been examined by Abramyan for free torsion of a rectangular box (6), and by Nowinski for constrained torsion of an annular sector (15a), while Arutyunyan

estimated the validity of Foeppl's formulas for torsional rigidity of rolled profile sections (7).

Although thin-walled bars can be frequently regarded as thin rods, their theory, so far, involves small deformations only, which in turn differentiates the theory concerned from the theory of thin rods with large deflections. An attempt has been made by Dzanelidze (8a) to unify the two theories.

Thin-walled bars may be roughly classified into the following groups, as far as the connectivity of the cross section, its uniformity, fixing conditions, and form of the longitudinal axis are concerned: (a) open and closed, (b) cylindrical and tapered (in the latter case, with small or high taper), (c) freely and rigidly supported (the mode of support being taken into account), (d) with straight or sweptback fixing, (e) with straight or curved axis. There are, in general, considerable differences in a theoretical approach to some of these problems and, historically, the particular theories developed, for a long time, in isolation.

During the first period, which ends approximately at the time of the Second World War, special attention was given mainly to the simplified solutions connected with the familiar theories of bending and torsion of beams. Later on a more refined approach was adopted (5b), (9), (15b). This concerns, in particular, constrained torsion (which requires more thorough treatment than constrained bending), then high taper and high sweepback (10a-d), (11), (133). A rigorous theory being considerably more complex than an engineer's one, simplifying assumptions have frequently been chosen, such as that of shear-resisting skin. In fact, the main difficulty of the theory involved did not consist in finding a stress system which would be statically equivalent to the applied load but in satisfying all other conditions (compatibility of strain, end conditions, etc.). To this end, supplementing the engineer's stress systems with sets of self-equilibrating stress systems—due to Ebner and Koeller (12b), and definitely developed by Argyris and Dunne (5b)—has been applied.

For a basic approach to the problem, some of the methods used are the following: a pure kinematic analysis of deformation of the bar, as in (13); mixed methods using the stress function notion (5b), (9), (10a-c), (14a); mixed methods using energy principles (14b), (133).

General reviews on various temperature effects in thin-walled structures have been recently presented by Hoff (16f), 1955, in Applied Mechanics Reviews, and Kitchenside (17), 1958, where an extensive bibliography on the subject may be found. We thus limit our attention to some separate papers, selected somewhat at random, dealing exclusively with thermoelastic problems for thin-walled bars, such as that by Heldenfels, 1950, treating a box beam (18), then by Parkes (19) who refined an earlier solution of Hoff for an idealized multicell wing. The same problem has been treated by Pohle and Oliver (20), and Goldberg (21), 1956, and by Shuh, 1955, who considered multicell beams using a numerical method (22). This method as well as that of (20) have been compared by Tramposh and Gerard, 1958. Loss of torsional stiffness of a thin double-edge due to heating has been evaluated by Budiansky and Mayers (23c), 1956. Recently, 1958, Kochanski and Argyris presented a theory of large thermoelastic deformations applied, in particular, to thin solid bars (24). An energy approach to thermoelastic problems, using thermodynamic potential and free energy concepts to generalize the theorems of Castigliano and Lagrange, is due to Hemp (25a), and has been applied to thin-walled open bars in (15f), 1957.

The restricted applicability of the Saint-Venant principle to thin-walled structures has been discussed by Vlasov (26a), Goodier and Barton (27h), Hoff (16e), and Dzanelidze and Panovko (8d), but no general explanation, indeed, could be given.

In recent years some monographs (5a,b,c), (10c), (28a), and books (8b), (29), (30), (31), (32b), (33) confined exclusively to the theory of thin-walled bars have been published. Extensive tables and graphs may be found in (5a), (34), and general information and methods in (16a), (28b,c), (35c), (35), (45b), as well as in (5d,j), (39). We now pass to our main objective which is a survey of more representative work on the subject. Because of the wealth of valuable papers, this survey makes no claim for completeness.

OPEN SECTIONS

The most representative of thin-walled bars are, perhaps, those with open sections, i.e. sections which do not contain any closed cell. Yet the middle line of the walls, at a cross section, may ramify as in double-tee beams or sheets stiffened with channels.

Apparently the theory of thin-walled open bars was influenced, although indirectly, by the classical work of Prandtl (37) and Michell (38) on lateral buckling of narrow beams, 1899. It is known that the torsional rigidity of an open bar is usually decomposed into a Saint Venant's, and a torsion-bending one. As far as the former is concerned, approximate solutions for rolled profile sections owe much to Prandtl's membrane analogy, 1903, used in experiments by Griffith and Taylor, 1917. This problem had been investigated earlier by Bredt (40), 1896. In 1924, Weber (41a,b) treated in detail torsional rigidity of composite thin sections. All this work has been recast by Foeppls in "Drang und Zwang," 1928.

Twenty years earlier, Timoshenko (28d) presented a solution concerning constrained torsion for a double-tee beam, assuming linear distribution of normal stress in the flanges. A third-order differential equation for the angle of twist has been obtained, from which both Saint-Venant and axial constrained stress systems could be determined. In this particular solution one may observe a seed of all future and general theories.

Further progress is due to Weber (41c,d) who, in 1926, extended Timoshenko's method to arbitrary double-flanged sections. In the meantime Timoshenko presented another solution of constrained torsion for a narrow rectangular section, using a method of Foeppl, which has also become classical (28h). Wagner, 1929, treated in a creative way the general problem of constrained torsion, in connection with an analysis of buckling by torsion and flexure (42a). His derivation is based on the cross-sectional warping concept generally adopted in most present work. Wagner's analysis has been corrected and supplemented (concerning four additional conditions of equilibrium) by Kappus (43), 1937, who gave an adequate picture of the displacement field for an open bar. Independently, Vlasov (26b,c) developed Wagner's idea, 1936, and Grzedzielski and Nowinski investigated the same problem (13) on a basis of their theory of thin-walled bars, 1938. Some inaccuracies involved have been corrected by the last author in 1947 (15c). In 1940, Vlasov published his book (26a) containing a comprehensive study of the equilibrium, stability and vibration of open sections, and which, basically, determined the development of the Russian school on the subject. Vlasov's theory concerns engineers' stress. Also polygonal sections with deformable contour have been treated and the results of experimental verification in CNIPS given by Rshanitsyn. For other experimental evidence see, e.g., (44b), and for bibliography of general experimental research on thin-walled bars—(5a), (34), (35c), (36), (45b), (46). A variational derivation of Vlasov's equations has been given by Dzanelidze (8c), 1943. In the 1940's Goodier published a series of studies in which he simplified the results of Kappus and gave a rigorous proof of the validity of Wagner's assumptions (27a,b). All research work concerning engineers' theories of bending, torsion and stability of open bars, up to 1945, has been unified by Timoshenko (28a). Clearly, those theories respecting first-order phenomena could not be accurate enough

in the vicinity of any source of constraint (such as rigid fixing and variation of load or cross section). Thus an exact mathematical theory, within the limits of its assumptions and involving all singularities and refinements, was needed. It has been given, in 1947–1949, by Argyris and Dunne (5b) and includes both open and closed, single and multicell arbitrary cross sections, as well as slight conical taper, slight sweepback, and arbitrary load. The main idea of the reference in question, concerning open sections, lies in resolving the true stress system into three components: an orthodox bending and torsion system, axial-constrained Wagner-Kappus system, and Argyris-Dunne self-equilibrating stress systems. The presence of the last systems admits the fulfillment of the conditions of compatibility and all other conditions involving modes of loading and support, thus providing an adequate solution of the problem. The 230-page treatise (5b), although not easy to study, deserves to be considered as an important contribution to the development of the theory of thin-walled bars. A summary of (5b) has been given by the authors in (5a), and for the open sections, by Argyris, in (5c). A somewhat similar theory, involving open as well as closed sections and using strain-stress function, has been given by Adadurov (9), 1947, whose earlier work on the subject remains partially unpublished (8b). An integrodifferential equation for the strain-stress function has been solved by Adadurov using expansion in the series of eigenfunctions, a procedure similar to (5b). For short tubes, a simplified solution combining the hypotheses of warping and of longitudinal inextensional deformation proposed by Umansky has been given by Maryin (47), 1950, and Goodier (27e) estimated the influence on the torsion case of an initial arbitrary distribution of axial stress. Another general solution, parallel to (5b), in terms of displacements, however, has been given in (15d,e) for an open tube with zero Saint-Venant torsional rigidity. Let us mention, finally, a simple method, valid for open as well as for closed and combinations of open and closed sections, given by Kármán and Christensen (48a) and based on the warping concept. An earlier rather similar approach is due to Hoff (16d). In a later paper (48b) Kármán and Wei-Zang Chien gave another simple solution of constrained torsion without making the assumption of zero rate of twist at the built-in section of the bar. Also Weber (41e), 1952, contributed to the engineers' solutions using energy method.

CLOSED SECTIONS

Torsion of arbitrary closed single cell sections, in the sense of simplified theory of Saint Venant, was considered by Bredt (40), 1896, who derived the two familiar formulas known as Bredt-Batho. They were generalized, using energy considerations, to multicell tubes by Lorenz (49) in 1913. The first investigation of constrained warping of a freely supported box beam under sine-wise distributed torque is attributed by Ebner to Eggenschwyler (50a). A fairly general investigation of a built-in cantilever box beam with linear, not necessarily conical, taper, under linearly varying torque, is due to Reissner (51), 1926. He used an analysis of elastic displacements and assumed an indeformability of the cross sections, as well as linear distribution of normal stress along the walls, which constituted a generalization of the Bernoulli hypothesis to thin-walled bars. Referring to (50a), (51) and to the, apparently, first investigation on shear lag problem in box beams by Schnadel (52a), Ebner (12a), 1933, treated a built-in tapered rectangular box beam, with a finite number of deformable cross-sectional ribs, under torsion load. In order to determine the redundancies, he used strain energy methods and independently established the equation of three axial forces, derived—according to (8b)—by Byelayev, 1922, when investigating a constrained torsion of a box beam with shear resisting skin (53). Ebner's paper served, and still serves, as a classical reference. At the same time, Atkin applied Timoshenko's energy method of determination of the coefficients of decay (28h) to the case of constrained torsion of a box beam (54a).

Much subsequent work on closed sections has been influenced by Williams. In 1934 (14a) he considered in detail constrained torsion of a uniform rectangular box under arbitrarily distributed, or concentrated, torque using a mixed method together with a stress function. Williams' analysis of displacements in constrained torsion revealed new facts. In another paper (14b), the shear stress in bending and the location of the flexural axis, for unsymmetrical sections, have been derived using an unpublished energy method of Fisher. The study of the flexural axis has been continued in (14c), with reference to trapezoidal and unsymmetrical stressed skin box beams with reinforcements. The first period described thus far may be brought to an end by quoting a semi-graphical approach of Kirste (55), still in use by some workers (56). This period is characterized by a discussion of rather restricted types of cross section of the bars. A more general theory of closed sections which resembles (48a) is attributed by (8b) to Umansky (57a), 1939, who departed from a "weakened" dependence of warping on the unit twist deduced from the Bredt-Batho equation. The intuitive result of Umansky was corrected by him in (57b). Later this method was based on energy considerations by Dzanelidze (8b). Constrained torsion of arbitrary cross sections has been also considered by Williams, with the help of Timoshenko's method for the determination of the decay of stress (14f). More recently, 1953, Ruffner and Hout (58) discussed torsion of rectangular, elliptical and airfoil box sections on the basis of the solution of Kármán and Chien, and Mansfield (59), using a particular approach, treated a box beam with a large number of webs as an elastic continuum. The last problem was reconsidered, more rigorously, by Wittrick (10e), and multicell box beams were analyzed by Hemp (25c), 1955, and by Argyris (5d), who used force and displacements methods, assuming the deformability of the ribs.

Evidently, most of the work on closed sections, reviewed above in a sample-like form, presents little unity in the sense that several special or engineer's solutions have been given. In fact, over the same period of time, methods of a more general character, involving the effect of taper and sweepback, have also been developed. These will be reviewed in the section which follows.

TAPER. SWEEPBACK. CURVED BARS.

Although some of the pre-war work has been concerned, incidentally, with the taper of the bars (e.g. (54b), by Atkin, where a tapered beam with booms is treated as a plane problem), more comprehensive studies on taper began during the war, and some have since been published. Thus Pflueger (60), 1942, gave a general engineer's analysis of a slightly conical stressed skin bar with arbitrary cross section. Also Cox published a series of reports (61a) on arbitrary tapered polygonal sections with shear resisting skin. He reduced the problem to a set of equations relating three successive boom forces and considered the deformability of the ribs and the cut-outs. In 1947, Balabukh (133) used strain energy methods to discuss slight conical taper and high cylindrical sweepback, and Tsibulya (62) extended Umansky's engineer's theory to slightly tapered beams, assuming rigid diaphragms in a spherical form. Also Kruszewski (63a) treated constrained torsion of conical box beams by a generalized method of Kuhn. In the same year, 1942, as already stated, the first part of the theory of Argyris and Dunne (5b) was published. Similarly as in the case of open tubes, the theory considered resolves the stress in the closed sections into two components: an ordinary engineer's flexure and torsion stress sys-

tem, and a (generally infinite) set of self-equilibrating stress systems. The latter can be represented by orthogonal functions, or eigenloads, in the case of a "similar" variation of the cross sections along the axis of the tube. This allows the satisfaction of all the required conditions. Semi-monocoque problems, i.e. problems concerning walls ineffective in normal strain, become particular cases of the general theory. In fact, slight taper and sweepback of both open and closed bars belong to the basic assumptions of the theory.

One of the first who considered highly skewed plate elements reinforced by stiffeners was Levy (64a), 1947. Levy's approach consisted in breaking the structure into elements and using Castigliano theorem for the computation of internal forces. He assumed chordwise elastic diaphragms. This approach was adopted later by Lang and Bisplinghoff (65), 1951, in a case of elastic normal diaphragms. They also gave a method of solution based on the principle of minimum potential energy in the case of rigid normal diaphragms. A general extension of the analysis (5b) to a vast class of problems involving high taper and high sweepback is due to Wittrick (10c), 1950, for rigid chordwise diaphragms. To simplify the calculations, Wittrick considered a single cell. He treated in detail a case of constant longitudinal thickness of the walls, exponential and sinusoidal forms of stress function, and linearly and exponentially varying load. The paper (10c) covers the author's previous work done with Thompson (10d), as well as the results of Thompson and of Fluegge (11) who, however, treated multicell tubes. A generalization of the theory in terms of displacements to doubly curved highly tapered bars of revolution has been given in (15h).

A different simplified approach, using Castigliano theorem, is due to Bodet (66), 1954, for high taper and sweepback, and in the same year Zender and Brooks tried to adapt the elementary theory to the basic types of sweepback (67c). On the basis of an analysis of an oblique anisotropic plate Hemp extended the usual engineer's theory to sweptback box beams with chordwise elastic ribs, using stress function concept (25b), 1955. Investigations by Noton (1) showed that, in case of sweepback, the theory of Hemp and that of Mansfield (68b) based on the deformability of ribs yield sufficiently close agreement with experiment at the sections remote from tip and root disturbances. The latter effects have been treated with success by Morley, 1952, and in 1956 (69) Miura presented a different idea to avoid the necessity of the consideration of the root triangle. More experimental evidence on sweepback may be found in (67a,b). Because of tedious calculations, MacNeal and Benscotter demonstrated the usefulness of analog computors in stress analysis of multicell sweptback bars (70).

Thin-walled bars with a curved axis have been treated extensively in a book by Umansky (57c), 1948, who adopted engineer's theory of open sections valid for straight bars. This approach has been refined by Grigoriev (71) and reconsidered by Wilde (72), 1956. Pretwisted thin-walled beams in bending were discussed by Zickel (73a), 1955, using Love's approach, and by Maunder (74), 1958, by means of energy methods.

CHARACTERISTIC POINTS

While the theory of bending of beams was clarified before the end of the nineteenth century, the notion of the center of shear (or of flexure) was not discovered until the 1920's, which, according to Westergaard, is strangely late. The location of the shear center which is of special importance in open sections has been extensively discussed with respect to another characteristic point, i.e. the center of twist (28c), (75). Some confusion still exists about these problems.

In 1904-1910 Bach, by investigating channels in bending, stated differences in twist caused by parallel shifting of load (76). These rather vague ideas of Bach were confirmed, in 1917, by Griffith and Taylor (77), and explained in an adequate way by Maillart (78), 1921, who introduced the notion of the center of shear. According to Maillart's definition a load which passes through the center of shear does not provoke any twist of the bar. Independently, Eggenschwyler (50b), 1920, arrived at the explanation of the problems concerned with flexure of unsymmetrical cross sections. Further progress was due to Weber (41c,d) who also gave an energy proof of the relative location of the two centers mentioned. Foeppls, in 1928, gave a systematic treatment of the problem on the basis of the results available at the moment, and Duncan (79a) derived an exact formula for the coordinates of the center of shear for very thin cross sections. In 1935, several authors discussed the same problem, e.g. Williams (14b), Schwalbe (80a), Fisher (14b) and Trefftz (81), the last two advocating the adoption of the center of least strain as an authentic center of flexure. By this center they understood a point through which the load passes if the strain energy of the bar should be a minimum. The point thus obtained does not coincide with the center of shear as defined previously. On the other hand, Leybenson (82) and Koiter (83a) advocated a kinematic definition of the center of shear. The kinematic definition was formulated rigorously, in 1938, by Stevenson (84) for the Saint-Venant case of bending and torsion. According to Stevenson, the location of the shear center has to be defined using the condition of zero mean twist of a section, which is automatically satisfied in the presence of rigid diaphragms. Stevenson's definition was also adopted by Goodier (27g). In 1938, Grzedzielski and Nowinski (13b) demonstrated that, for freely supported cantilever, the center of twist can be located at an arbitrary point of the cross section; they also introduced a condition of minimum square warping. Weinstein (88) showed that when a similar condition is satisfied the centers of shear and twist coincide. Certain confusions existing in the literature concerning the centers of twist and shear have been discussed by Neuber (85), Osgood (86), Jacobs (87), Duncan (79b), Koiter (83b) and Schwalbe (80b), 1941-1954.

While a rigorous definition of the center of shear can be given for uniform thin-walled bars, it seems impossible to give an adequate definition in the presence of nonuniformity of the cross section, taper, sweepback and curvature of the axis of the bar. A comprehensive analysis of the subject for slight taper and sweepback has been given in (5a,b), and for high taper in (10c).

The effect of the curvature of the axis of the bar on the location of the center of shear has been discussed in an elementary way by Johnson (89), in 1956.

As a fourth characteristic point, at the cross sections of the thin-walled bars, some authors adopt the center (and the axis) of zero warping (5a,b), (90).

DIFFUSION

Departures from the engineers' stress distribution in a thin wall with heavy longitudinal members can be, in fact, dealt with by a general theory of axial constraint, like that given in (5b). Yet historically, the phenomenon of shear lag, or diffusion of load from a boom into a stiffened panel, developed separately. After the first investigations, apparently due to Schnadel (52a), shear lag problems have been studied, among others, by Cox and his coworkers (61b), and by Kuhn (92a), 1937. In the first stage, the shear lag problem has been given two different treatments: by Duncan and Cox (79c) who considered a restricted number of stiffeners, and by Williams and his coworkers who used a stringer-sheet model equivalent to an infinite number of stiffeners (14d,e). The former method assumed that the sheet is incapable of carrying direct stress, while the latter method, conversely, attributed to the sheet an infinite transverse rigidity. The problem was simultaneously

considered by Schapitz and his coworkers (93), and by Reissner (94a) who gave a simple treatment of a box beam assuming a degenerated transverse orthotropy of the sheets, 1938. A stringer-sheet model has been also used by Fine (95a), by Fine and Hopkins (95b), and by Hemp (25d), 1943. A quite general method of Cox (61c) for a finite number of stiffeners has been generalized by Argyris and Cox (5g), 1944, and, in 1944–1946, Argyris gave a rigorous solution valid for any number of stiffeners (25h,i), a limit case of which is the stringer-sheet method. A comprehensive summary of the last papers can be found in (5a), 1952.

Several least-work solutions are due to Reissner and his coworkers (94b,c), (96b), and a refinement of their work as well as of the work of Kuhn (92a,b) has been given, using plane stress function, by Hildebrand (96a), 1943. In a later paper (94d), 1946, Reissner gave a minimum potential energy analysis of the problem, which yielded a generalized differential equation of bending in the sense that a term resulting from the shear deformation of the sheet was involved.

Another stringer-sheet solution is due to Goodey (97), who gave two methods, of different accuracy, using Fourier integrals in the more rigorous approach. A paradox of an infinite stress at a point of the free edge adjacent to the boom, and connected with the stringer-sheet model, has been cleared up by Mansfield (68a), 1949, by introducing the flexibility of the rivets. In 1954, Mitchell (98) discussed a semi-infinite strip with two flanges and an infinite half-sheet with a single boom, using Fourier integrals, and obtained some exact solutions. Another exact solution for a rectangular finite sheet on an elastic foundation has been obtained recently by Caldwell (99), 1958. So far only the linear elastic case of diffusion has been treated. Recently, however, the case of nonlinear elasticity, arising when the flanges are loaded beyond the proportional limit, has been studied by complementary energy methods by M. M. Chen, 1958.

STABILITY. VIBRATION

Three types of instability of a thin-walled bar are more characteristic than others: (a) over-all lateral, (b) over-all flexural-torsional, and (c) local. As far as the first type is concerned, papers (37), (38) have already been mentioned. Furthermore, in 1913, Timoshenko solved the problem of lateral buckling of a double-tee beam using his energy method (28e), and Bleich treated the case of unequal flanges for the elastic and plastic ranges (35a), while Chwalla discussed taper (100a). The case of a nonsymmetrical double-tee beam under constant bending moment has been also treated by Hill (44a), and a general discussion for an arbitrary cross section, in the frame of his general theory of stability, has been given by Goodier (27b), 1942.

As stated previously, the foundations of the theory of the flexural-torsional instability have been formulated in (28d), (42a), (43), (26a), (27a,b). Independently, Lundquist and Fligg, 1937, corrected Wagner's hypotheses and assumed that the location of the center of twist is determined by the condition of minimum critical load (101b). The fundamental equations of the problem have also been derived by means of energy considerations by Bleich (35b) and corrected in (35c). A strain energy derivation of flexural-torsional buckling load for open sections has likewise been given by Hoff (16b), 1943. His and his coworkers extensive studies on stability of thin-walled structures, 1944–1949, cleared up to a large extent the instability problems of thin-walled structures (16c).

As far as local buckling is concerned, it is difficult to draw a line between primary and secondary buckling. Thus the torsional buckling of an angle was once considered as a local failure (28i). An analysis of local buckling of channels, double-tee and zee sections, with due regard to the interaction between the walls, has been given by Lundquist (101c), 1939, and Kimm (102). Similar problems have been treated by Lundquist and Stowell (101d), (103c). In 1943, Nylander contributed to the effect of web deformation on the local buckling of double-tee beams (106), and Goodier and Barton (27h) reconsidered the same problem from the point of view of torsion.

The problem of the instability of an assembly of elements has been treated by Lundquist, Stowell and Schuette (101e), since, in fact, not a single plate element but rather a whole assembly of the elements becomes unstable.

Initial instability of a combination of plate and stiffeners under compressive load was formerly predicted by the buckling strength of the plate and the failing load of this combination—by means of the effective width of the plate. This rough approach has been gradually superseded. Thus a study on over-all initial instability of stiffened plates under various load is due to Timoshenko (28f), who frequently used an energy approach. Similar problems have been studied by Lokshin (104) who considered a restricted type of load, by Barbré (105) and Chwalla (100b), who demonstrated the influence of torsional rigidity of stringers. Mention should also be made of a general analysis by Donnell involving panels between and across stiffeners (107). Buckling of bars restrained by sheets and the influence of constrained axis of rotation have been considered by Goodier (27b) and reconsidered by Weibell (108), 1945, using Fourier-Levy expansions. A detailed analysis of both symmetric and antisymmetric, torsional, flexural and local modes of buckling of sheet and stringer combinations has been given by Argyris (5e), 1944, and elucidated with Dunne (5a), 1954. A simple treatment is due to Argyris (5f), 1954.

Both primary and local, elastic and plastic instability of extrusions, in a simplified manner, corroborated by tests, has been discussed by Ramberg and Levy (109), 1945. A comparison of several methods of calculating compressive failure of sheet and stringer combinations, based on Kármán's effective width criterion (48c) and a method of Newell, was done by Lundquist (101f), but no rigorous theory of postbuckling behavior and failure of such combinations exists. Comprehensive discussion may be found, e.g., in (5a), where a bibliography of NACA experimental work has been listed.

As stated before, we shall not discuss here classical problems, such as initial instability of webs, or problems concerning plates, such as their postbuckling behavior. In the former case we refer to the extensive bibliography, up to 1956, given in (5a), (35c), (110), (111), (28b), (36), while in the latter case the papers of Schnadel (52b), Kármán and his coworkers (48c), Timoshenko (28b), Marguerre (112a,b), and a more recent series of studies of Levy in NACA publications are to be mentioned.

The diagonal fields of tension in buckled webs were first studied, in a simplified way, by Wagner (42c), 1929, and investigated experimentally by Lahde and Wagner. A more refined treatment involving flexural rigidity of the web is due to Kromm and Marguerre (113), 1937, while an extensive experimental program, under the guidance of Kuhn, has been conducted by NACA, leading to a semi-empirical theory of incomplete tension field (92c), 1947. Another theoretical analysis has been given by Levy and his coworkers (64b,d), 1946, and, in 1948, Bergman discussed the same problem using the Ritz method (114). Bergman's analysis took account of the interaction of the sheet and stiffening members. Also Waestlund and Bergman (115) gave a comprehensive study, both theoretical and experimental, on the subject, 1947. Recently Aare (116), 1955, called attention to discrepancies between his results based on the large deflection theory of plates and those derived from the theory of diagonal tension field.

Let us now say a few words about the vibrations of thin-walled bars. They were discussed in a general manner, and the respective equations for coupled torsional-flexural and longitudinal vibrations are to be found, in a book by Vlasov

(26a), 1940. Vlasov considered arbitrary open bars with or without longitudinal end loads. Independently, Garland (117), 1940, investigated complex flexural and torsional vibrations of cantilevers using the Rayleigh-Ritz method, while Timoshenko (28g) considered a similar problem for a simply supported channel, and Federhoffer (118) solved a general case for asymmetrical cross section. Transverse vibrations of hollow thin-walled beams, including the influence of secondary effects, were discussed by Budiansky and Kruszewski (23a), while Kruszewski and Kordes (63b) considered similar effects for torsional vibrations, and Budiansky and Frailich (23b) investigated a coupling mechanism between local and over-all vibrations of box beams. Torsional vibrations for open rolled profile sections and various end conditions were considered also by Gere (119a). Also Gere and Lin (119b) gave a rigorous treatment of triple coupling.

FRAMEWORKS

In the past decade, special methods of computation of frameworks made of rolled profile sections, using engineer's theories of bending and torsion of thin-walled open bars, have been adopted. The idea is due mainly to Gorbunov (32a) and was developed by Gorbunov and Stryelbitskaya (32b,c), Bitchkov (120), Stavraki (121a) and Karyakin (122). Stavraki also considered spacial stability of frameworks from the same theoretical standpoint (121b). The main idea of Gorbunov's method consists in using Vlasov's equations for calculation of torsion-bending quantities, the fixing conditions of the bars at the nodes being rigorously analyzed. In the deformation method of solution, additional equations for the equilibrium of the binoments at the nodes determine the unknown warping. Force methods of solution have also been used.

ELASTIC-PLASTIC RANGE

In treating the vast field of inelastic phenomena we shall confine ourselves to a few observations concerning thin-walled bars.

Prager (123) has made fundamental remarks on combined torsion and extension of tubes. Statical computations concerning the elastic-plastic state of arbitrary open sections were made by Meshlumyan (91), 1950–1951, for strain-hardening material under constrained torsion. The main idea on the subject consists in considering a "reduced area" of the cross section which leads to equations for stresses which are formally similar to those given by Wagner and Kappus. He also introduced the notion of a kinematic center which is different from the shear center, beyond the elastic limit. A different discussion of the kinematic center is given in (2). A method similar to that of Meshlumyan for closed sections has been adopted by Besukhov (124). In 1953 Barrett (125) used an accurate strain-stress curve to discuss pure plastic bending of double-tees and channels, and recently plastic bending of asymmetric angle beams has been considered by Abramson and his coworkers (126), 1955. Elastic-plastic deformation of slender sections was treated by Carter (127), 1958.

Limit states of double-tee beams using limit diagrams of torsion-bending stresses were discussed by Stryelbitskaya in (128a) and in a more general way in (128b), 1954. Similar problems have been considered by Panovko (129) on the basis of the work of Rshanitsyn who gave, 1942–1949, an analysis of the limit states for ideally plastic material.

Thin-walled members under creep have been recently analyzed by Pandalai and Pater, 1958, using an elastic analog proposed by Hoff which reduces the problem to one of linear elasticity.

Plastic buckling of configurations of plates has been discussed by Stowell (103a), 1948, on the basis of his theory involving the relations of Ilyushin. The same problem with reference to H and Z sections has been further discussed by Stowell and Pride (103b), 1949, and by Onat and Drucker (130), 1953, who applied the incremental theory to the cruciform section. Their results were extended, in 1956, by Besseling (131) to an initially twisted strut. Flexural-torsional buckling of open sections, beyond the elastic range, was also discussed by Roik (132), 1956.

REFERENCES

1 Noton, B. R., A swept cantilever box beam with two spars and skew ribs, *Aircr. Engng.* **27,** 317, 204–215; **27,** 318, 256–261, 1955.

2 Huan-Ke-Chshi, Basic equations of the theory of open thin-walled bars at the elastic limit (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 122–136, 1957.

3 Rabotnov, J. N., Basic equations of the theory of shells (in Russian), *Doklady Akad. Nauk SSSR, (N.S.)* **17,** no. 2, 1945.

4 Goldenveizer, A. L., On the theory of thin-walled rods (in Russian), *Prikl. Math. Mekh.* **13,** 6, 561–596, 1949.

5 Argyris, J. H., (a)—and Dunne, P. C., Structural Analysis, Part 2 of Structural principles and data, Handbook of aeronautics, no. 1, London, Sir Isaac Pitman and Sons, Ltd., 1952; (b)—and Dunne, P. C., The general theory of cylindrical and conical tubes, *J. Roy. Aero. Soc.* **51,** 199–269, Feb.; **51,** 757–783, Sept.; **51,** 884–930, Nov. 1947; **53,** 461–483, May; **53,** 558–620, June 1949; (c) The open tube, *Aircr. Engng.* **26,** 301, 102–112, 1954; (d) Energy theorems and structural analysis, *Aircr. Engng.* **26,** 308, 347–356; **26,** 309, 383–394; **26,** 310, 410–422, 1954; **27,** 312, 42–58; **27,** 313, 80–94; **27,** 314, 125–134; **27,** 315, 145–158; (e) The initial instability and failure of flat stiffened panels under compression, Feb. 1944 (unpublished); (f) Flexure-torsion failure of panels, *Aircr. Engng.* **26,** 304, 174–184; **26,** 305, 213–219, 1954; (g)—and Cox, H. L., Diffusion of load into stiffened panels of varying section, *Aero. Res. Comm. Lond. Rept. Mem.* 1969, 1944; (h) Diffusion of symmetrical loads into stiffened parallel panels with constant area edge members, *Aero. Res. Comm. Lond. Rept. Mem.* 2038 (1944); (i) Diffusion of antisymmetric concentrated end loads and edge loads into parallel stiffened panels and analysis of parallel panels under transverse load, *Aero. Res. Comm. Lond. Rept. Mem.* 2882 (1946); (j) On the analysis of complex elastic structures, AMR **11** (1958), 331–338 (Feature Article).

6 Abramyan, B. L., Torsion and bending of prismatic bars with hollow rectangular section (in Russian), *Prikl. Math. Mekh.* **14,** 3, 265–276, 1950.

7 Arutyunyan, N. Kh., Solution of a problem concerning torsion of bars with polygonal cross section (in Russian), *Prikl. Math. Mekh.* **13,** 1, 107–112, 1949.

8 Dzanelidze, G. J., (a) On the theory of thin and thin-walled bars (in Russian), *Prikl. Math. Mekh.* **13,** 6, 597–608, 1949; (b)—and Panovko, J. G., Statics of thin-walled rods (in Russian), Gos. Izdvo Tekhn.-Teor. Lit., Leningrad-Moscow, 1948; (c) Variational formulation of the Vlasov theory of thin-walled rods (in Russian), *Prikl. Math. Mekh.* **7,** 6, 455–462, 1943; (d)—and Panovko, J. G., Saint-Venant's principle and its application to the theory of plates and shells (in Russian), "Computation of three-dimensional structures." Vol. 1, 329–342, Izdvo Min. Stroit. Predpr. Mashin., Moscow, 1950.

9 Adadurov, R. A., (a) Shearing stress in thin-walled structures near the built-in end (in Russian), *Trudi Centr. Aerogidrodin. Inst.* no. 614, 1947; (b) Stresses and deformations in cylindrical shell with rigid diaphragms (in Russian), *Doklady Akad. Nauk SSSR* **62,** 2, 1948.

10 Wittrick, W. H., (a) Preliminary analysis of a highly swept cylindrical tube under torsion and bending, *Aero. Res. Rep.* ACA-39 (Austr.), May 1948; (b) Conical tubes with high taper and sweep under torsion and bending loads, *Aero. Res. Lab. Rep.* SM 117 (Austr.), Aug. 1948; (c) Torsion and bending of swept and tapered wings with rigid chordwise ribs, *Aero. Res. Cons. Comm. Rep.* ACA-51, Sept. 1950; (d) Thompson, J. J., and—, The stresses in certain cylindrical swept tubes under torsion and bending, *Aero. Res. Rep. ACA* 43 (Austr.), Jan. 1949; (e) Torsion of a multiwebbed rectangular tube, *Aircr. Engng.* **25,** 298, p. 372, 1953; AMR **7** (1954), Rev. 1059.

11 Fluegge, Statique de l'aile en flèche, Part 1, Les bases de la méthode de calcul, *ONERA Publ.* no. 24, Paris, 1949.

12 Ebner, H., (a) Die Beanspruchung duennwandiger Kastentraeger auf Drillung, *Z. Flugtechn. Motorlsch.* **23,** 645–655; **24,** 684–692, 1933; (b)—and Koeller, H., Zur Berechnung des Kraftverlaufes in versteiften Zylinderschalen, *Lufo* **14,** 12, 1937.

13 Grzedzielski, A., and Nowinski, J., (a) Formulae for stress computation in thin-walled structures (in Polish), *Inst. Techn. Lotn.* Warsaw, 1938; (b) Center of shear and center of twist in thin-walled beams (in Polish), *Techn Lotn.*, no. 1, 1–5, 1939.

14 Williams, D., (a) Torsion of a rectangular tube with axial constraints, *Aero. Res. Comm. Lond. Rep. Mem.* 1619 (1934); (b) Some features of the behaviour in bending of thin-walled tubes and channels. *Aero. Res. Comm. Lond. Rep. Mem.* 1669 (1935); (c)—and Fairbank, D. W. G., A study of the flexural axis positions for certain box sections, *Aero. Res. Comm. Lond. Rep. Mem.* 1751 (1936); (d)—, Starkey, R. D., and Taylor, R. H., *Aero. Res. Comm. Lond. Rep. Mem.* 2098 (1939); (e)—and Fine, M., Stress distribution in reinforced flat sheet cylindrical sheils and cambered box-beams under bending action, *Aero. Res. Comm. Lond. Rep. Mem.* 2099 (1940); (f)—and Fine, M., The effect of end constraint on thin-walled cylinders subject to torque, *Aero. Res. Comm. Lond. Rep. Mem.* 2223 (1945).

15 Nowinski, J., (a) The torsion of a bar with cross section in the form of an annular sector, one cross section remaining plane, *Arch. Mech Stos.* **9,** 1, 73–87, 1957; (b) Theory of thin-walled conical beams (in Polish), *Prace Gl. Inst. Lotn.* no. 1, 3–47, 1951; (c) Torsion of beams with open cross section (in Polish) *Biul. Inst. Techn. Lotn.* no. 6, 32–45, 1947; (d) On the theory of thin-walled open beams under uniformly distributed load (in Polish), *Rozpr. Mat.* no. 1, 1–48, 1952; (e) Thin-walled cylindrical tube with open cross section loaded arbitrarily, *Bull. Acad. Pol. Sci., Cl. IV,* **4,** 4, 275–281, 1956; AMR **10** (1957), Rev. 1381; (f) The principle of stationary free energy in the thermoelastic analysis of thin-walled tubes, *Arch. Mech. Stos.* **9,** 3, 359–368, 1957; AMR **11** (1958), Rev. 2030; (g) On the incorrectness of a theorem stating identity of center of shear and of center of twist (in Polish), *Arch. Mech. Stos.* **3,** 1, 53–60, 1951; (h) Thin-walled doubly curved structural elements with high taper, Proc. First Congr. Theor. Appl. Mech., Indian Inst. of Technol., Kharagpur, Nov. 1955, 61–64.

16 Hoff, N. J., (a) The analysis of structures, New York, J. Wiley and Son, Inc., 1956; (b) A strain energy derivation of the torsional-flexural buckling loads of straight columns of thin-walled open sections, *Quart. Appl. Math.* **1,** 4, 341–345, 1944; (c)—and coworkers, The inward bulge-type buckling of monocoque cylinders, Parts I to V, *NACA TN's* 938 (1944), 939, 968 (1945), 1499, 1505 (1948); Stresses in and general instability of monocoque cylinders with cutouts, Parts I to VIII, *NACA TN's,* 1013, 1014 (1946), 1263 (1947), 1264, 1435, 1436 (1948), 1962, 1963 (1949); (d) Stresses in space-curved rings reinforcing the edges of cut-outs in monocoque fuselages, *J. Roy. Aero. Soc.* **17,** 35–83, Jan. 1943; (e) The applicability of Saint-Venant's principle to airplane structures, *J. Aero. Sci.* **12,** 4, p. 455, 1945; (f) High temperature effects in aircraft structures, AMR **8** (1955), 453–456 (Feature Article).

17 Kitchenside, A. W., The effects of kinetic heating on aircraft structures, *J. Roy. Aero. Soc.* **62,** 566, 105–117, 1958.

18 Heldenfels, R., (a) The effect of nonuniform temperature distributions on the stresses and distortions of stiffened-shell structures. *NACA TN's* 2240. 2241. (1950); (b)—. Zender. G. A., and Libove, C., Stress and distortion analysis of a swept box beam having bulkheads perpendicular to the spars, *NACA TN* 2232 (1950).

19 Parkes, E. W., Transient thermal stresses in wings, *Aircr. Engng.* **25,** 298, 373–378, 1953.

20 Pohle, F. V., and Oliver, H. J., Temperature distribution and thermal stresses in a model of a supersonic wing, *J. Aero. Sci.* **21,** 1, 8–16, 1954; AMR **7** (1954), Rev. 1638.

21 Goldenberg, M. A., Investigation of the temperature distribution and thermal stresses in a hypersonic wing, *J. Aero. Sci.* **23,** 11, 981–990, 1956; AMR **10** (1957), Rev. 1920.

22 Schuh, H., Transient temperature distributions and thermal stresses in a skin-shear web configuration at high-speed flight for a wide range of parameters, *J. Aero. Sci.* **22,** 12, 829–836, 1955; AMR **9** (1956), Rev. 1973.

23 Budiansky, B., (a)—and Kruszewski, E. T., Transverse vibrations of hollow thin-walled cylindrical beams, *NACA TN* 2682 (1952); AMR **6** (1953), Rev. 1173; (b)—and Frailich, R. W., Effects of panel flexibility on natural vibration frequencies of box beams, *NACA TN* 3070 (1954); AMR **7** (1954), Rev. 3482; (c)—and Mayers, J., *J. Aero. Sci.* **23,** 12, 1081–1093, 1956; AMR **10** (1957), Rev. 2235.

24 Kochanski, S. L., and Argyris, J. H., Some effects of kinetic heating on the stiffness of thin wings, *Aircr. Engng.* **29,** 344, 310–318, 1957; **30,** 348, 32–40, 1958; AMR **11** (1958), Revs. 2525 and 3956.

25 Hemp, W. S., (a) Fundamental principles and theorems of thermoelasticity, *Aero. Quart.* **7,** 184–192, Aug. 1956; (b) On the application of oblique coordinates to problem of plane elasticity and sweptback wing structures, *Aero. Res. Counc. Lond. Rep. Mem.* 2754 (1955); (c) Stress analysis of multiweb boxes, Proc. Fifth Intern. Conf., Los Angeles, June 1955, 146–161, New York, Inst. Aero. Sci., Inc.; AMR **10** (1957), Rev. 2905; (d) "Exact" theory for a uniform symmetrical wing with an infinite number of rigid ribs, *Aero. Res. Comm. Lond. Rep. Mem.* 6995 (1943).

26 Vlasov, V. Z., (a) Thin-walled elastic rods (in Russian), Gos. Izdvo Stroit. Lit., Moscow-Leningrad, 1940; (b) New method of computing prismatic beams composed of thin-walled sections under axial, bending and torsion loads (in Russian), *Proy. i Standart* nos. 8–9, 10, 1936; (c) *Prikl. Math. Mekh.* **3,** no. 1, 1939.

27 Goodier, J. N., (a) The buckling of compressed bars by torsion and flexure, Cornell Univ. Engng. Exp. Sta. Bull. no. 27, 1941; Flexural-torsional buckling of bars of open sections, under bending, eccentric thrust or torsional loads, Cornell Univ. Engng. Exp. Sta. Bull. no. 28, 1942; (b) Torsional and flexural buckling of bars of thin-walled open section under compressive and bending loads, *J. Appl. Mech.* **9,** 3, A-103-107, 1942; (c) Torsional and flexural buckling of bars of thin-walled open section under compressive and bending loads, *J. Appl. Mech.* **10,** 2, A-110-111, 1943; (d) On combined flexure and torsion, and the flexural buckling of a twisted bar, *Quart. Appl. Math.* **2,** 2, 93–101, 1944; (e) Elastic torsion in the presence of initial axial stress, *J. Appl. Mech.* **17,** 4, 383–387, 1950; (f) Engel, H. L., and —, Measurements of torsional stiffness changes and instability due to tension, compression and bending, *J. Appl. Mech.* **20,** 553–560, Dec. 1953; (g) A theorem on the shearing stress in beams with applications to multicellular sections, *J. Aero. Sci.* **11,** 3, 272–280, 1944; (h)—and Barton, M. V., The effect of web deformation on the torsion of I-beams, *J. Appl. Mech.* **2,** 1, A-35-40, 1944.

28 Timoshenko, S., (a) Theory of bending, torsion and buckling of thin-walled members of open cross-section, *J. Franklin Inst.* **239,** 3, 201–219; **239,** 4, 249–268; **239,** 5, 343–361, 1945; (b) Theory of elastic stability, McGraw-Hill Book Co., New York, 1936; (c)—and Goodier, J. N., Theory of elasticity, McGraw-Hill Book Co., New York, 1951; AMR **5** (1952), Rev. 43; (d) Lateral stability of a double-tee beam, *Bull. Polyt. Inst.*, St. Petersburg, Vols. 4, 5, 1905–1906; (e) Sur la stabilité des systèmes élastiques, *Ann. Ponts Chauss.* (9) Parts 3–5, 1913; (f) Ueber die Stabilitaet versteifter Platten, *Eisenbau* **12,** p. 147, 1921; (g)—and Young, D. H., Vibration problems in engineering, D. Van Nostrand Co., Inc., New York, 1955; AMR **9** (1956), Rev. 1713; (h) On the torsion of a prism, one of the cross sections of which remains plane, *Proc. Lond. Math. Soc.* (2) **20,** p. 389, 1921.

29 Kan, S. N., and Panovko, J. G., Elements of structural analysis of thin-walled structures (in Russian), Gos. Izdvo Obor. Prom., Moscow, 1952.

30 Rutecki, J., Strength of thin-walled structures (in Polish), Panstw. Wydawn. Nauk., Warsaw, 1957.

31 Urban, I. V., (a) Theory of structures composed of thin-walled rods, Izdvo TZDI, Moscow, 1955; (b) Theory of torsion-bending of open and closed thin-walled structures (in Russian), Izdvo MEMIT, Moscow, 1950.

32 Gorbunov, B. N., (a) Computation of three-dimensional frames composed of thin-walled rods (in Russian), *Prikl. Math. Mekh.* **7,** 1, 65–70, 1943; (b)—and Stryelbitskaya, A. I., Theory of frameworks composed of thin-walled bars (in Russian), Gos. Izdvo Tekhn.-Teor. Lit., Leningrad-Moscow, 1948; (c)—and Stryelbitskaya, A. I., Strength computation of thin-walled bar systems (in Russian), "Computation of three-dimensional structures," Vol. 1, 97–162, Izdvo Min. Stroit. Predpr. Mashin., Moscow, 1950.

33 Teofanov, F. I., Computation of thin-walled structures (in Russian), Oborongiz, Moscow, 1953.

34 The Royal Aeronautical Society, Stressed skin structures data sheets, London.

35 Bleich, F., (a) Stahlhochbauten, Vol. 2, Julius Springer, Berlin, 1933; (b)—and Bleich, H., Bending torsion and buckling of bars composed of thin walls, Prelim. Publ., 2nd Congr. Intern. Assoc. Bridge Struct. Engng., Berlin, 1936; (c)—and Bleich, H., Buckling strength of metal structures, McGraw-Hill Book Co., New York, 1952; AMR **5** (1952); Rev. 1037.

36 Peery, D. J., Aircraft structures, McGraw-Hill Book Co., New York, 1950.

37 Prandtl, L., Kipperscheinungen, (dissert.), Nurenberg, 1899.

38 Michell, A. G. M., Elastic stability of long beams under transverse forces, *Phil. Mag.* **48,** p. 298, 1899.

39 Pratusevitch, J. A., Variational methods in structural mechanics (in Russian), Gos. Izdvo Tekhn.-Teor. Lit., Moscow-Leningrad, 1948.

40 Bredt, R., Kritische Bemerkungen zur Drehungselastizitaet, *ZVDI* **40,** 28, 785–790; **40,** 29, 813–817, 1896.

41 Weber, C., (a) Die Lehre der Drehungsteifighkeit, *VDI Forschheft.* no. 249, 1924; (b) Der Verdrehungswinkel von Walzeisentraegern, A. Foeppl-Festschrift, Berlin, 1924; (c) Biegung und Schub in geraden Balken, *ZAMM* **4,** 4, 334–348, 1924; (d) Uebertragung des Drehmomentes in Balken mit doppelflanschigem Querschnitt, *ZAMM* **6,** p. 85, 1926; (e) Constrained torsional warping (in German), *ZAMM* **32,** 10, 305–307, 1952; AMR **6** (1953), Rev. 1561.

42 Wagner, H., (a) Verdrehung und Knickung von offenen Profilen, Festschr. 25 J. Hochsch. Danzig, A. W. Kaffemann, Danzig,

1929; (b)—and Pretschner, W., Verdrehung und Knickung von offenen Profilen, *Lufo* **11**, 6, 174–180, 1934; (c) Ebene Blechwandtraeger mit sehr duennem Stegblech, *Z. Flugtechn. Motorlsch.* **20**, 8, 200–207; **20**, 9, 227–233; **20**, 10, 256–262; **20**, 11, 279–284; **20**, 12, 306–314. 1929.

43 Kappus, R., (a) Drillknicken von Staeben mit offenem Profil, *Jahrb. Deutsch. Lufo* 1–409, 1937; (b) Drillknicken zentrisch gedrueckter Staebe mit offenem Profil im elastischen Bereich, *Lufo* **14**, 9, 444–457, 1937.

44 Hill, H. N., (a) The lateral instability of unsymmetrical I-beams, *J. Aero. Sci.* **9**, 4, 175–180, 1942; (b) Torsion of flanged members with cross sections restrained against warping, *NACA TN* 888 (1943).

45 Niles, A. S., (a) Experimental study of torsional column failure, *NACA TN* 733 (1939); (b)—and Newell, J. S., Airplane structures, J. Wiley and Sons, Inc., New York, 1946.

46 Gerard, G., and Becker, H., Handbook of structural stability, Parts 1 to 5, *NACA TN's* 3781–3785 (1957); AMR **11** (1958), Revs. 822, 1570–1572.

47 Maryin, N. A., Approximate method of computing short open shells (in Russian), "Computation of three-dimensional structures," Vol. 1, 219–248, Izdvo Min. Stroit. Predpr. Mashin., Moscow, 1950.

48 Kármán, T., (a)—and Christensen, N. B., Methods of analysis for torsion with variable twist, *J. Aero. Sci.* **11**, 2, 110–124, 1944; (b)—and Wei Zang Chien, Torsion with variable twist, *J. Aero. Sci.* **13**, 10, 503–511, 1946; (c)—, Sechler, E. E., and Donnell, L. H., The strength of thin plates in compression, *Trans. ASME* **54**, APM 54-5, pp. 53–57, 1932.

49 Lorenz, H., Technische Elastizitaetslehre, R. Oldenbourg, Munich-Berlin, 1913.

50 Eggenschwyler, A., (a) Ueber die Drehungsbeanspruchung rechteckiger Kastenquerschnitte, *Eisenbau* **9**, 3, 45–53, 1918; (b) Zur Festigkeitslehre, *Schweiz. Bauztg.* **76**, 18, 206–208; **76**, 23, p. 266, 1920.

51 Reissner, H., Neuere Probleme aus der Flugzengstatik, *Z. Flugtechn. Motorlsch.* **17**, 7, 137–146; **17**, 9, 179–185; **17**, 18, 384–393, 1926.

52 Schnadel, G., (a) Die mittragende Breite in Kastentraegern und im Doppelboden *Werft. Reed. Hafen* **9**, 5, p. 92, 1928; (b) Die Ueberschreitung der Knickgrenze bei duennen Platten, Proc. 3rd Intern. Congr. Appl. Mech., Stockholm, 1930.

53 Byelayev, V. N., Computation of full-cantilever wings (in Russian), *Tekhn. Vozd. Flota*, nos. 7–9, 1932.

54 Atkin, E. H., (a) Stresses in metal-covered planes, *Aircr. Engng.* **5**, 53, 162–164, 1933; (b) Tapered beam, *Aircr. Engng.* **10**, 117, 347–351, 1938; **10**, 118, 371–374, 1938.

55 Kirste, L., *Aeronaut.* nos. 212, 216, 1937.

56 Astakhov, M. F., et al, Handbook of structural analysis of airplane (in Russian), Oborongiz, Moscow, 1954.

57 Umansky, A. A., (a) Bending and torsion of thin-walled aircraft structures (in Russian), Oborongiz, Moscow, 1939; (b) Normal stress in torsion of aircraft wing (in Russian), *Tekhn. Vozd. Flota* no. 12, 1940; (c) Three-dimensional structures (in Russian), Stroyizdat, Moscow, 1948.

58 Ruffner, B. F., and Hout, E., Stresses and deformations in wings subject to torsion, *NACA TN* 2600 (1952); AMR **5** (1952), Rev. 2012.

59 Mansfield, E. H., Torsional stresses in multi-webbed rectangular cylinders, *Aircr. Engng.* **25**, 287, 20–21, 1953; AMR **6** (1953), Rev. 2733.

60 Pflueger, A., Spannungsverteilung in Stabfoermigen Membran-Kegelschalen, *ZAMM* **22**, 2, 99–116, 1942.

61 Cox, H. L., (a) On the stressing of polygonal tubes with particular reference to the torsion of tapered tubes of trapezoidal section, *Aero. Res. Comm. Lond. Rep. Mem.* 1908 (1942); (b)—, Smith, H. E., and Conway, C. G., Diffusion of concentrated loads into monocoque structures, *Aero. Res. Comm. Lond. Rep. Mem.* 1780 (1937); (c) Diffusion of concentrated loads into monocoque structures, *Aero. Res. Comm. Lond. Rep. Mem.* 1860 (1938).

62 Tsibulya, B. P., (a) Bending and torsion of conical wing and fuselage shells (in Russian), *Trudi VVIA im. Zhukovskovo* no. 253, 1947; (b) Bending and torsion of thin-walled conical shells (in Russian), "Computation of three-dimensional structures," Vol. 1, 249–276, Izdvo Min. Stroit. Predpr. Mashin., Moscow, 1950.

63 Kruszewski, E. T., (a) Bending stress due to torsion in a tapered box beam, *NACA TN* 1297 (1947); (b)—and Kordes, E. E., Torsional vibrations of hollow thin-walled cylindrical beams, *NACA TN* 3206 (1954); AMR **8** (1955), Rev. 2982.

64 Levy, S., (a) Computation of influence coefficients for aircraft structures with discontinuities and sweepback, *J. Aero. Sci.* **14**, 10, p. 547, 1947; (b)—, Fienup, K. L., and Wooley, R. M., Analysis of square shear web above buckling load, *NACA TN* 962 (1945); (c)— and Kroll, W. D., Primary instability of open section stringers attached to sheet, *J. Aero. Sci.* **15**, 10, 580–591, 1948; (d)—, Woolley, R. M., and Corrick, J. N., Analysis of deep rectangular shear web above buckling load, *NACA TN* 1009 (1946).

65 Lang, A. L., and Bisplinghoff, R. L., Some results of swept-back wing structural studies, *J. Aero. Sci.* **18**, 11, 705–717, 1951.

66 Bodet, P., Contribution to the structural analysis of swept wings, *Aircr. Engng.* **26**, 305, 208–212, 1954.

67 Zender, G. A., (a)— and Libove, C., Stress and distortion measurements in a 45° swept box beam subjected to bending and torsion, *NACA TN* 1525 (1948); (b)—and Heldenfels, R., Stress and distortion measurements in a 45° swept box beam subjected to antisymmetrical bending and torsion, *NACA TN* 2054 (1950); (c)— and Brooks, W. A., An approximate method of calculating the deformations of wings having swept, M or W, Λ, and swept-tip planforms, *NACA TN* 2978 (1953); AMR **7** (1954), Rev. 1088.

68 Mansfield, E. H., (a) Rivet flexibility and load diffusion, *Aircr. Engng.* **21**, 242, 96–98, 1949; (b) Elasticity of sheet reinforced by stringers and skew ribs, with applications to swept wings, *Aero. Res. Counc. Lond. Rep. Mem.* 2758, 1949; AMR **7** (1954), Rev. 2837.

69 Miura, K., An approximate solution for stresses and deformations of swept wing, Proc. Sixth Japan Nat. Congr. Appl. Mech., Univ. Kyoto, 1956, 39–42; AMR **11** (1958), Rev. 4004.

70 MacNeal, R. H., and Benscotter, S. U., Analysis of swept-back wings on Cal-Tech analog computer, *NACA TN* 3115 (1954); AMR **7** (1954), Rev. 3138.

71 Grigoriev, J. P., On a computation of curved thin-walled bars (in Russian), "Computation of three-dimensional structures," Vol. 1, 175–218, Izdvo Min. Stroit. Predpr. Mashin., Moscow, 1950.

72 Wilde, P., Curved beams of thin-walled open sections (in Polish), *Arch. Mech. Stos.* **8**, 1, 41–50, 1956; AMR **10** (1957), Rev. 1082.

73 Zickel, J., (a) Bending of pretwisted beams, *J. Appl. Mech.* **22**, 3, 348–352, 1955; AMR **9** (1956), Rev. 1039; (b) Pretwisted beams and columns, *J. Appl. Mech.* **23**, 2, 165–175, 1956.

74 Maunder, L. J., Bending of pretwisted thin-walled beams, *J. Appl. Mech.* **25**, 1, 67–74, 1958.

75 Sokolnikoff, I. S., Mathematical theory of elasticity, McGraw-Hill Book Co., New York, 1956; AMR **9** (1956), Rev. 2849.

76 Bach, C., (a) Versuehe ueber die tatsaechliche Widerstandsfaehigkeit von Balken mit [-foermigem Querschnitt, *ZVDI* **53**, 44, 1790–1795, 1909; (b) *ZVDI* **54**, 10. 382–387. 1910.

77 Griffith, A. A., and Taylor, G. I., The problem of flexure and its solution for the soap film method, *Aero. Res. Comm. Lond. Rep. Mem.* 399 (1917).

78 Maillart, R., (a) Zur Frage der Biegung, *Schweiz. Bauztg.* **77**, 18, 195–197, 1921; (b) Der Schubmittelpunkt, *Schweiz. Bauztg.* **83**, 10, 109–111, 1924.

79 Duncan, W. J., (a) The torsion and flexure of cylinders and tubes, *Aero. Res. Comm. Lond. Rep. Mem.* 1444. (1932); (b) The flexural center or center of shear, *J. Roy. Aero. Soc.* **57**, 513, 594–597, 1953; AMR **7** (1954), Rev. 2768; (c)—and Cox, H. L., Diffusion of load in certain sheet-stringer combinations, *Aero. Res. Comm. Lond. Rept. Mem.* 1825. (1938).

80 Schwalbe, W. L., (a) Ueber den Schubmittelpunkt in einem durch eine Einzellast gebogenen Balken, *ZAMM* **15**, 3, 138–143, 1935; (b) *J. Roy. Aero. Soc.* **58**, p. 728, 1954.

81 Trefftz, E., Ueber den Schubmittelpunkt in einem durch eine Einzellast gebogenen Balken, *ZAMM* **15**, 4, 220–225, 1935.

82 Leybenson, L. S., On the shear center of closed thin-walled sections (in Russian), *Dokladi Akad. Nauk SSSR* **3**, 5, 1935.

83 Koiter, W. T., (a) Versl. Verh., Nat. Lucht. Lab. 8, p. 171. 1939; (b) The flexural centre or centre of shear, *J. Roy. Aero. Soc.* **58**, p. 64, 1954.

84 Stevenson, A. C., Flexure with shear and associated torsion in prisms of uniaxial and asymmetric cross sections, *Phil. Trans. Roy. Soc. (A)* **237**, 161–229, 1938–1939.

85 Neuber, H., Schubmittelpunkt und Querschnittsverwoelbung duennwandiger Traeger unterhalb der Beulgrenze, *ZAMM* **21**, 2, 91–95, 1941.

86 Osgood, W. R., The center of shear again, *J. Appl. Mech.* **10**, 2, A-62-64, 1943.

87 Jacobs, J. A., The center of shear of aerofoil sections, *J. Roy. Aero. Soc.* **57**, p. 235, 1953.

88 Weinstein, A., The center of shear and the center of twist, *Quart. Appl. Math.* **5**, 1, 97–99, 1947.

89 Johnson, W., (a) The effect of curvature on the center of shear, *J. Roy. Aero. Soc.* **59**, 536, 562–565, 1955; AMR **9** (1956), Rev. 3932; (b) The twist due to bending moment in cantilevers curved in plan, *J. Roy. Aero. Soc.* **60**, 544, 277–281, 1956; AMR **9** (1956), Rev. 3552.

90 Dunne, P. C., A method of stressing the singly symmetrical trapezoidal tube, Boulton Paul Aircr. Ltd. TN 23, Feb. 1945.

91 Meshlumyan, R. A., (a) Torsion and flexure of thin-walled cylindrical shells beyond the elastic limit (in Russian), *Prikl. Math. Mekh.* **14**, 3, 253–264, 1950; (b) Carrying capacity of thin-walled structures of strain-hardening material (in Russian), *Prikl. Math. Mekh.* **15**, 2, 175–182, 1951.

92 Kuhn, P., (a) Stress analysis of beams with shear deformation of flanges, *NACA Rep.* 608, (1937); (b)—and Chiarito, P. T., Shear lag in box beams, *NACA Rep.* 739, (1942); (c)—and Peterson, J. P., Strength analysis of stiffened beam webs, *NACA TN* 1364 (1947).

93 Schapitz, E., Feller, H., and Koeller, M., *Lufo* 1938.

94 Reissner, E., (a) On the problem of stress distribution in wide-flanged box-beams, *J. Aero. Sci.* **5,** 8, 295–299, 1938; (b) Least-work solutions of shear lag problems, *J. Aero. Sci.* **8,** 7, 284–291, 1941; (c)—and Newell, J., Shear lag in corrugated sheets used for the chord member of a box beam, *NACA TN* 791 (1941); (d) Analysis of shear lag in box beams by the principle of minimum potential energy, *Quart. Appl. Math.* **4,** 3, 268–278, 1947.

95 Fine, M., (a) A comparison between plain and stringer reinforced sheet from the shear lag standpoint, RAE Rep. SME 3182, ARC 5495. (1941); (b)—and Hopkins, G., Stress diffusion adjacent to gaps in the interspar skin of a stressed skin wing. RAE Rep. AD 3208. (1942).

96 Hildebrand, F. B., (a) The exact solution of shear lag problems in flat panels and box beams assumed rigid in the transverse direction, *NACA TN* 894 (1943); (b)—and Reissner, E., Least-work analysis of the problem of shear lag in box beams, *NACA TN* 893 (1943).

97 Goodey, W. J., Stress diffusion problems, *Aircr. Engng.* **18,** 208, 195–198; **18,** 209, 227–230; **18,** 210, 271–276; **18,** 211, 313–316; **18,** 212, 343–346; **18,** 213, 385–389; 1946.

98 Mitchell, L. H., A Fourier integral solution for the stresses in a semi-infinite strip, *Quart. J. Mech. Appl. Math.* **7,** 51–56, 1954; AMR **8** (1955), Rev. 49.

99 Caldwell, J. B., Diffusion of load from a boom into a rectangular sheet, *Quart. J. Mech. Appl. Math.* **11,** 1, 73–87, 1958; AMR **11** (1958), Rev. 3481.

100 Chwalla, E., (a) Die Kipp-Stabilitaet gerader Traeger mit doppelt-symmetrischem I-Querschnitt, Forschhefte Geb. Stahlb., no. 2, Julius Springer, Berlin, 1939; (b) Das allgemeine Stabilitaetsproblem der gedrueckten, durch Randwinkel verstaerkten Platte, *Ing.-Arch.* **5,** 1, 54–65, 1934.

101 Lundquist, E. E., (a) On the strength of columns that fail by twisting, *J. Aero. Sci.* **4,** 6, 249–253, 1937; (b)—and Fligg, C. M., A theory for primary failure of straight centrally loaded columns, *NACA TR* 582 (1937); (c) Local instability of centrally loaded columns of channel section and Z-section, *NACA TN* 722 (1939); (d) Local instability of symmetrical rectangular tubes under axial compression, *NACA TN* 686 (1939); (e)—, Stowell, E. Z., and Schuette, E. H., Principles of moment distribution applied to stability of structures composed of bars or plates. *NACA WRRL*-326. (1943); (f) Comparison of three methods for calculating the compressive strength of flat and lightly curved sheets and stiffener combinations, *NACA TN* 455 (1933).

102 Kimm, Beitrag zur Stabilitaet duennwandiger ⌈-Profile mit konstanter Wandstaerke im elastischen Bereich, *Lufo* **18,** 5, p. 155, 1941.

103 Stowell, E. Z., (a) A unified theory of plastic buckling of columns and plates, *NACA TN* 1556 (1948); (b)—and Pride, R. A., Plastic buckling of extruded composite sections in compression, *NACA TN* 1971 (1949); (c)—and Lundquist, E. E., Local instability of columns with I, Z, channel and rectangular-tube sections, *NACA TN* 743 (1939).

104 Lokshin, A. S., On the calculation of plates with ribs (in Russian), *Prikl. Math. Mekh.* **2,** 2, 225–240, 1935.

105 Barbré, R., (a) Beulspannungen in Rechteckplatten mit Laengssteifen bei gleichmaessiger Druckbeanspruchung, *Bauingen.* **17,** 268, 1936; (b) Stabilitaet gleichmaessig gedrueckter Rechteckplatten mit Laengs-oder Quersteifen, *Ing.-Arch.* **8,** 2, 117–150, 1937.

106 Nylaender, H., Drehungsvorgaenge und gebundene Kippung bei geraden, doppelt-symmetrischen I-Traegern, *Ing. Vetensk. Akad. Handl.* **174,** Stockholm, 1943.

107 Donnell, L. H., The stability of isotropic or orthotropic cylinders or flat or curved panels, between and across stiffeners, *NACA TN* 918 (1943).

108 Weibell, E. E., Buckling of stiffener and elastic sheet combinations under pure bending, *J. Aero. Sci.* **12,** 4, 393–402, 1945.

109 Ramberg, W., and Levy, S., Instability of extrusions under compressive loads, *J. Aero. Sci.* **12,** 4, 485–498, 1945.

110 Broude, B. M., Stability of plates in steel structures (in Russian), Izdvo Min. Stroit, Predpr. Mash., Moscow, 1949.

111 Volmir, A. S., Flexible plates and shells (in Russian), Gos. Izdvo Tekhn.-Teor. lit., Moscow, 1956.

112 Marguerre, K., (a)—and Trefftz, E., Ueber die Tragfaehigkeit eines laengsbelasteten Plattenstreifens nach Ueberschreiten der Beullast, *ZAMM* **17,** 2, 85–100, 1937; (b) Die mittragende Breite der gedrueckten Platte, *Lufo* **14,** 121, 1937.

113 Kromm, A., and Marguerre, K., Verhalten eines von Schub und Druckkraeften beanspruchten Plattenstreifens oberhalb der Beulgrenze, *Lufo* **17,** 62, 1937.

114 Bergman, S., Behaviour of buckled rectangular plates under the action of shearing forces, *Kungl. Tekn. Hogsk.*, Stockholm, 1948.

115 Waestlund, G., and Bergman, S. G. A., Buckling of webs in deep steel I-girders, *Publ. Int. Assn. Bridge Struct. Engng.* **8,** 891, 1947.

116 Aare, I. I., Investigation of postbuckling behavior of a resisting panel of a steel girder (in Russian), *Trudi Tal. Polyt. Inst.* **65,** 61–75, 1955.

117 Garland, C. F., The normal modes of vibrations of beams having noncollinear elastic and mass axes, *J. Appl. Mech.* **7,** 3, A-97-105, 1940.

118 Federhoffer, K., Free vibrations of straight bars with thin-walled and open cross section (in German), *Sitzber. Akad. Wiss. Wien,* Abt. 2a, **156,** p. 343, 1947.

119 Gere, J. M., (a) Torsional vibrations of beams of thin-walled open section, *J. Appl. Mech.* **21,** 4, 381–387, 1954; AMR **8** (1955), Rev. 1932; (b)—and Lin, Y. K., Coupled vibrations of thin-walled beams, *J. Appl. Mech.* **25,** 3, 373–378, 1958.

120 Bitchkov, D. V., Computation of beam and frame systems composed of thin-walled bars (in Russian), Stroyizdat, Moscow, 1948.

121 Stavraki, L. N., (a) Strength computation of three-dimensional structures composed of thin-walled bars with open symmetrical profile (in Russian), "Computation of three-dimensional structures," Vol. 2, 171–233, Gos. Izdvo Lit. Stroit. Archit., Moscow, 1951; (b) Stability of three-dimensional structures composed of thin-walled bars (in Russian). *Sbornik Inst. Stroit. Mekh.* no. 12, Akad. Nauk. USSR Kiev, 1950.

122 Karyakin, N. J., (a) *Trudi MEMIIT,* no 57, 1949; no 60, 1951, Transsheldorizdat; (b) Torsion of thin-walled bars and frames (in Russian), Izdvo MEMIIT, Moscow, 1950.

123 Prager, W., On the interpretation of combined torsion and tension tests of thin-walled tubes, *NACA TN* 1501 (1948).

124 Besukhov, I. I., Theory of elasticity and plasticity, Gos. Izdvo Tekhn.-Teor. Lit., Leningrad-Moscow, 1953.

125 Barrett, A. J., The bending of some common beam sections into the plastic range, *J. Roy. Aero. Soc.* **57,** 506, 110–115, 1953; AMR **6** (1953), Rev. 3067.

126 Abramson, H. N., Williams, H. A., and Woolpert, B. G., An investigation of the bending of angle beams in the plastic range, *J. Aero. Sci.* **22,** 12, 818–828, 1955; AMR **9** (1956), Rev. 1759.

127 Carter, W. J., Torsion and flexure of slender solid sections, *J. Appl. Mech.* **25,** 1, 115–121, 1958.

128 Stryelbitskaya, A. I., (a) Limit state of a double-tee beam in constrained torsion (in Russian), *Sbornik Trudi Inst. Stroit. Mekh.* no. 14, Akad. Nauk USSR, Kiev, 1950; (b) *Sbornik Trudi Inst. Stroit. Mekh.* no. 19, Akad. Nauk. USSR, Kiev, 1954.

129 Panovko, J. G., Limit states of thin-walled cylindrical structures (in Russian), "Computation of three-dimensional structures," Vol. 2, 103–147, Gos. Izdvo Lit. Stroit. Archit., Moscow, 1951.

130 Onat, E. T., and Drucker, D. C., Inelastic instability and incremental theories of plasticity, *J. Aero. Sci.* **20,** 3, 181–186, 1953; AMR **6** (1953), Rev. 3397.

131 Besseling, J. F., Analysis of the plastic collapse of a cruciform column with initial twist loaded in compression, *J. Aero. Sci.* **23,** 1, 49–53, 1956; AMR **9** (1956), Rev. 1423.

132 Roik, Torsion-flexural buckling of centrally compressed columns with open cross section in the nonelastic regime (in German), *Stahlbau* **25,** 1, 10–17, 1956; **25,** 2, 32–35, 1956; AMR **9** (1956), Rev. 2507.

133 Balabukh, L. I., Strength computation of conical tubes, *Trudi Centr. Aerogidrodin. Inst.* no. 640, 1947.

Analytical Methods in Applied Mechanics

(See also Revs. 1671, 1672, 1682, 1692, 1695, 1700, 1716, 1718, 1726, 1857, 1881, 1931, 1940, 2109, 2132)

Book—1649. Wills, A. P., Vector analysis with an introduction to tensor analysis, New York, Dover Publications, Inc., 1958, xxxii + 285 pp. $1.75. (Paperbound)

1650. Shaikevich, V. D., Determination of the numerical value of the matrix operator in calculations of regular systems (in Russian), *Sb. nauch. tr. Dnepropetr. inzh.-stroit. in-ta* no. 1–2, 176–192, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4859.

An investigation is made of matrix regulating rod systems in the calculation of which it is essential to determine the value of the operator K performing, in its capacity of a matrix focal relation, linear conversions of vectors of the unknowns in conditions of an infinite basic system; K is a quadratic matrix of the n-th degree satisfying the equation

$$F(K) = AK^2 + BK + C = 0 \qquad [1]$$

where A, B, C are known quadratic matrices. These equations are solved in the usual manner [see Gantmakher, "Matrix theories," Gostekhizdat, 1953]. Let $f(\lambda) = |F(\lambda)|$ be a polynomial of degree $m \leqslant 2n$. By virtue of the generalized Caley theorem $f(K) = 0$ and the minimum polynomial of matrix K is a divisor $f(\lambda)$. When all the matrices N_1, $N_2 \ldots$ of degree n, having a normal Jordan form, the minimal polynome of which is a divisor $f(\lambda)$, K is sought in the form $K = P_i N_i P_i^{-1}$. From this point, for the elements of matrix P_i a system of linear equations is obtained

$$AP_iN_i^2 + BP_iN_i + CP_i = 0 \qquad [2]$$

Criteria are established for the selection, from the large number of solutions obtained in this way, of that solution which would satisfy the conditions of the given engineering problem. From the condition of the finite nature of the potential energy of the deformed system (which leads to the convergence of some infinite matrix series) it follows that none of the natural values of K should exceed a modulus of 1. Further, only a case is investigated of real and simple natural values of the operator K (neither reasons nor criteria for this are advanced). It is asserted that in among S non-zero (this is a mistake: it should have been stated: non-zero and unequal with reference to a unit modulus) roots of polynomial $f(\lambda)$ $\frac{1}{2}$ S roots should, according to the modulus, be greater than 1. Therefore the selection of Matrix N_i is completely definite. Then all the solutions for P_i in Equation [2] are found, and it is shown that for all these values of P_i, $P_iN_iP_i^{-1}$ has the same value. The exposition is carried out on similar lines for regular systems of the first and second order. G. N. Chebotarev

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Book—1651. de Bruijn, N. G., Asymptotic methods in analysis, (Monographs on pure and applied mathematics, Vol. IV), New York, Interscience Publishers, Inc., 1958, xii + 200 pp. $5.75.

This is a valuable book. Asymptotics is not new. Its importance in pure and applied mathematics has been recognized since the days of Laplace. In applied problems the need for asymptotic estimates of series, integrals and other expressions is of frequent occurrence. Though numerous books contain some information on asymptotics, the material for the most part is presented only as extensively as necessary for the purpose at hand. The present volume is the first textbook on the subject and certainly the first to cover many aspects of this broad field. The tome fills a void in the literature and will be of frequent use to the applied worker.

Many important asymptotic methods are developed. Each is illustrated by a worked example with considerable attention to detail. Results are not formulated in all possible generality, for it is the author's thesis that generalization leads to stating "more and more about less and less." Asymptotic methods are flexible and generalization is restrictive. Asymptotics is very pragmatic and one's approach should reveal as much as possible in a given situation.

The introduction is basic to the entire volume. Apart from this, the remainder may be read independently, with the exception of chapters 4, 5 and 6 which are interrelated. The latter chapters deal with Laplace-type integrals and the saddle-point method. Author's vivid presentation of the saddle-point method is the best seen by the reviewer. Chapter 2 concerns implicit functions while chapter 3 is devoted to summation. Chapter 7 takes up indirect asymptotics. Iterated functions is the subject of chapter 8. A short discussion of differential equations is given in chapter 9. For further information on differential equations see the useful monograph "Asymptotic expansions" by A. Erdelyi, Dover, 1956, and the references given there.

Exercises are given at the end of each chapter and a few references are sprinkled throughout the text. Admittedly, the volume is not intended as an encyclopedia on asymptotics; nevertheless, a more complete bibliography would enhance the book. In any event, the reader will find the treatise useful and an enlightening source of ideas for the solution of asymptotic problems.

Y. L. Luke, USA

1652. Bedel'baev, A. K., Construction of A. M. Lyapunov's functions to give them quadratic form (in Russian), *Izv. Akad. Nauk. KazSSR Ser. Matem. i Mekhan.* no. 4, 24–37, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5171.

A system of differential equations is examined

$$\dot{\eta}_s = \sum_{k=1}^{n} c_{sk}\eta_k \quad (s = 1, \ldots, n) \qquad [1]$$

where c_{sk} = constants, roots of the characteristic equation $\Lambda(p) = 0$ satisfy the condition $\mathrm{Re}\, p_\lambda < 0$ $(\lambda = 1, \ldots, n)$. Formulas are deduced determining the coefficients of the quadratic form V – the Lyapunov function for equation [1]. Function V is expressed through the integrals from the fundamental solutions $\eta_{ks}(t)$ of system [1]. These integrals are reduced to the operational conception of function $\eta_{ks}(t)$ which is expressed through the coefficients of the original system [1]. It is maintained that this method of solution leads to more simple computations than is the case when using other known ways of calculating the coefficients of Lyapunov's quadratic functions. The constructed forms for V are applied to the problem of calculating the time of the transition process, employing the method proposed by N. G. Chetaev [*Prikl. Mat. Mekh.* **15**, 3, 371–372, 1951].

Note by the abstractor: The series of formulas used by the author are correct (without reservations) only in the case of simple roots for p, which in the arrangement used for the problem is not queried. But if some of the roots are close to each other the formulas, it appears, might give significant margins of error due to small errors in c. N. N. Krasovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1653. Sundstrom, M., and Flodin, K., Spectral densities dependent on two frequencies and their use in the study of linear, stochastic differential equations with time-dependent coefficients (in English), *Roy. Inst. Technol. Dept. Aero. Engng., Stockholm, KTH-Aero TN* 43, 8 pp., 1957.

If $x(t)$, $y(t)$ are input, output of system described by a linear differential equation with time-varying coefficients a_i, then modified

Fourier transforms ${}_TF_x(\omega) = \int_{-T/2}^{T/2} x(t)\exp(-j\omega t)dt$, etc. are corrected by ${}_TF_y(\rho) = \int_{-\infty}^{\infty} Y(\omega,\rho)\,{}_TF_x(\omega)d\omega$. Paper studies properties of mean spectral density $E[T^{-1}\,{}_TF_x(\omega)\,{}_TF_y^*(\rho)]$ when $\{x\}$ and $\{a_i\}$ are independent, stationary and ergodic, stochastic processes. Numerical example treated has autocorrelation $\exp(-k|\tau|)$. Applications are reserved for companion paper (title source TN44).

N. Ream, England

1654. Kravtchenko, J., and Apté, A., Note on Fourier's method of integration of equations of mathematical physics (in French), *Ann. Inst. Fourier, Univ. Grenoble* **7**, 329–358, 1957.

Solutions of boundary-value problems in the form of series of orthogonal functions are frequently presented without convergence proof. Authors show by example that such a proof can be constructed by elementary means. The series converge sufficiently rapidly to permit differentiation term by term provided the problem has been recast, as one may, in the form of an inhomogeneous equation with homogeneous boundary conditions.

C. M. Ablow, USA

1655. Schubert, H., The third kind of boundary-value problem for a cylinder of infinite length at both ends (in German), *ZAMM* **38**, 5/6, 194–199, May/June 1958.

Paper contains the solution of the problem of finding a potential function for a circular region when a linear combination of the normal derivative and the function is prescribed on the boundary. Starting with Poisson's integral formula for the circle, the solution of the two-dimensional problem and its analogy with the axisymmetric case is noted. An analogous well-known representation for three dimensions is used to get an integral equation for the density distribution. Fourier's transform is used to solve it, and an explicit integral representation of the solution is obtained and verified.

B. R. Seth, India

1656. Arzhanykh, I. S., Integral equations of basic problems in field theory (in Russian), *Trudî In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 13, 19–41, 1954; *Ref. Zh. Mekh.* no. 7, 1957; Rev. 7469.

Integral equations are deduced for the determination of vector V in accordance with differential equations

$$\text{rot } v = \Omega, \qquad \text{div } v = \theta$$

and in the region corresponding to the boundary conditions, delimited by a simple closed surface. Examples investigated are taken from hydrodynamics, theory of elasticity and electrodynamics.

V. A. Prokof'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Book—1657. Doetsch, G., Introduction to the theory and application of the Laplace transformation—A textbook for students of mathematics, physics and the engineering sciences [Einfuhrung in theorie und anwendung der LaPlace-transformation—Ein lehrbuch fur studierende der mathematik, physik und ingenieurwissenschaft], Stuttgart, Birkhauser Verlag Basel, 1958, 301 pp. DM 39.40.

Author of the present volume has previously published an exhaustive three-volume reference work on the Laplace transform. [See AMR **5** (1952), Rev. 1939; AMR **10** (1957), Revs. 1, 2003.] A number of books on the subject or books containing material on the subject emphasize the applications, and, in many instances, the mathematical properties receive only a sketchy or loose treatment. The present volume fills a gap in the literature between the author's own reference work and books for engineers. It maintains a high standard of rigor and is designed as a textbook for students of mathematics, physics and the engineering sciences.

The fundamental properties of the Laplace transform are carefully developed. Some further topics are differential equations, difference equations, complex inversion formula, asymptotics, partial differential equations and integral equations. A number of the ideas are illustrated with examples, but there are no problems. A few references are given, principally those not recorded in the handbook.

Y. L. Luke, USA

Book—1658. Franklin, P., An introduction to Fourier methods and the Laplace transformation, New York, Dover Publications, Inc., 1958, x + 289 pp. $1.75. (Paperbound)

1659. Jury, E. I., and Mullin, F. J., A note on the operational solution of linear difference equations, *J. Franklin Inst.* **266,** 3, 189–205, Sept. 1958.

The very advanced techniques employed throughout do not seem to be mathematically justified either in the text or in references and all results given can be obtained by elementary means. It is doubtful that there are engineering grounds for preference of the more difficult techniques. For those applications where numerical values or graphs are the end results (the authors offer such results in profusion) direct numerical generation from the recursions defined by the difference equations is almost always preferable to numerical evaluation of closed form solutions.

The first two cases treated, concerning one equation and many equations with constant coefficients, should be treated as one case; the homogeneous part always can be solved by substitutions of the type $x_n = \xi^n$, and particular solutions are equally trivial to generate for the three examples given. The same technique can be used to solve the next case, that of "equations whose coefficients are periodic functions," but here one solves an associated difference equation with constant coefficients and substitutes this answer into the original difference equation in an appropriate way. The fourth and fifth cases concern "periodic coefficients" for one and two equations of the first order and again should be treated as one case. They can be solved by repeated applications; for example, the solution to $X_{n+1} = a_n X_n$ is obviously $X_n = \left(\prod_{i=0}^{n} a_i\right) X_0$ even if a_n is a matrix and X_n a vector.

Initial conditions are brought into consideration in example 1 in a nonstandard way of questionable value. This method, which involves an unorthodox interpretation of the meaning of initial values, is not sufficiently explained—in fact, reviewer is only guessing at how initial conditions have been used—and this reflects on the exposition in general which, in the opinion of the reviewer, is nowhere up to mathematical standards.

H. M. Lieberstein, USA

1660. Salzer, H. E., Tables for the numerical calculation of inverse Laplace transforms, *J. Math. Phys.* **37,** 2, 89–109, July 1958.

Suppose that $F(p)$ is the Laplace transform of $f(t)$. Then $f(t)$ is given by the well-known complex inversion formula. If $F(p)$ is not too complicated, $f(t)$ is obtained by a suitable contour integral. In many problems, however, the integrations are extremely involved. The article under review seeks to get around this difficulty by resorting to approximate methods. It is assumed that $F(p)$ may be approximated by $\sum_{r=1}^{m} \beta_r/p^2$ to the required degree of accuracy. Under this assumption on $F(p)$ the complex inversion integral is approximated and tables are constructed which enable one to find $f(t)$ for certain values of t. A number of examples are given to illustrate the use of the tables.

E. J. Scott, USA

Book—1661. Gruss, G., Calculus of variations [Variationsrechnung], Heidelberg, Quelle & Meyer, 1955, viii + 282 pp.

This is the revised second edition of a book published in 1938. It was written as an introductory textbook for students of mathe-

matics, physics, and engineering. The reader is assumed to have a good command of differential and integral calculus and also a little working knowledge of differential equations.

Limiting the discussions to the simplest problem type, chapter 1 deals with the first variation (Euler's equation), chapter 2 the second variation (Legendre and Jacobi conditions), and chapter 3 the Weierstrass conditions, in a concise, sufficiently rigorous, and readable style. Then the theory extends naturally into chapter 4, the theory of Jacobi and Hamilton, and chapter 5, the variation problem between a point and a curve. Chapter 6 treats the Weierstrass theory concerning the variation problem in parameter expression. Chapter 7 shows the generalization of the theory in the sense of inclusion of higher derivatives, or more than one unknown functions, or double integral, or side conditions. The book concludes with newly written chapter 8 (direct methods; eigenvalue problems).

Reviewer comments that the book adequately covers highlights of the theoretical foundations of calculus of variations, the invaluable tool for physicists and engineers. As a textbook, however, it must be supplemented by a series of exercises taken from some other source. If one does not mind a little increase in volume, addition of discussions on Friedrichs' (or involute) transformation, and also inequalities as the side condition, would add much to the usefulness of the book, which is already very usable.

S. Moriguti, Japan

1662. Arsen'ev, Yu. D., Principles of approximate similarity applications (in Russian), *Teploenergetika* **4,** 3, 55–56, Mar. 1957.

In order to obtain full similarity between the model and nature a great number of criteria must be fulfilled simultaneously. This is seldom possible and approximate similarity can be used. In previous papers evaluation was made of distortion of the function $\phi(\pi_1, \pi_2 \ldots \pi_n)$ due to variation in some parameter π_k. Absolute and relative distortion were examined by methods of theory of errors. Criterion for validity of approximate similarity is established in this paper. It has been shown that absolute similarity for a parameter is not necessary, provided the general principle of approximate similarity is fulfilled, particularly in the case π_k = const for model and nature. Analysis should be carried out to separate parameters having principal importance from those of secondary importance.

P. Bielkowicz, USA

1663. Engel, F. V. A., Non-dimensional groups as criteria of process plant dynamics, *Engineer, Lond.* **206,** 5357, 479–484, Sept. 1958.

Similarity and model research have been extensively based on nondimensional groups. These groups should also be used as important tools and criteria in investigating process plant dynamics. In general, the application of such groups has been badly handicapped by their apparently unrestricted number. The main task of the present investigation is to limit the number of the groups pertinent to fluid dynamics and heat transfer.

Axiomatic outlines and the comprehensive set of differential equations result in six groups. Stringent rules for the integral components of the groups are required. The velocity term is an essential integral component of each genuine group of dynamics. The Strouhal number is introduced as characterizing the unsteady state. Each of the six groups represents a distinct quality or feature, indicated by their position in the axiomatic system, as well as their relation to special terms in basic differential equations. The meaning of "completeness" of the system of groups is discussed, which differs from previous publications on this subject. The genuine groups are dealt with as "independent" variables characterizing irreversible processes. Their practical application is somewhat restricted by lack of information on the correct manipulation of the groups.

The present investigation indicates certain limits in the mathematical manipulation. It is recommended that the genuine nondimensional groups of dynamics should be applied separately, and merely as "test functions."

From author's summary

1664. Kelley, J. E., Jr., An application of linear programming to curve fitting, *J. Soc. Indust. Appl. Math.* **6,** 1, 15–23, Mar. 1958.

Theory of minima of convex functions is applied to the problem of minimizing the maximum absolute value of the difference between a function and its approximation over a finite set of points on the real axis. A linear programming formulation is given for an approximating function consisting of a sum of n or less functions defined over a set of m or less points where m in general is much larger than n. Because each point gives rise to one restraint equation, author develops a dual formulation of the problem. A 7-step algorithm is given for the special case of polynomial curve fitting. Process allows n to be unspecified in advance. Hence an approximation can be obtained by the simplex to meet a preassigned error tolerance.

Reviewer believes exposition would have been enhanced by discussion of relevant experience with method when applied to computing machinery.

R. B. Grant, USA

1665. Harling, J., Simulation techniques in operations research—a review, *Operat. Res.* **6,** 3, 307–319, May/June 1958.

1666. Hanka, W., Equations predict chance of misfit in assembly, *Prod. Engng.* **29,** 21, 61–63, May 1958.

1667. Weston, V. H., Toroidal wave functions, *Quart. Appl. Math.* **16,** 3, 237–257, Oct. 1958.

The Helmholtz equation is solved in toroidal coordinates. A complete set of solutions is obtained representing radiations from a ring source.

From author's summary

1668. Trent, H. M., On the construction of schematic diagrams for mechanical systems, *J. Acoust. Soc. Amer.* **30,** 8, 795–800, Aug. 1958.

The role that is played by a schematic diagram in the analysis of a mechanical system is discussed. Having defined the function of these diagrams, it is then possible to collect together those ideas and principles on the basis of which a systematic technique for constructing these diagrams can be evolved. Illustrations of the process are given.

From author's summary

1669. Bushuev, L. P., Graphic analysis of the motion of a straight round cylinder in a round cylindrical tube under the effect of variable-direction forces (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 159–161, June 1956.

1670. Lipson, M. A., Graphic method for determining the supporting capacity of ore blocks (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 131–136, May 1956.

Computing Methods and Computers

(See also Revs. 1717, 1718, 1764, 1888, 1909)

1671. Schmidtmayer, J., Linear computations over a complex field, *J. Roy. Aero. Soc.* **62,** 570, 451–455 (*Tech. Note*), June 1958.

Solving a system of linear algebraic equations, inversion of a matrix and evaluation of a determinant in the field of complex numbers are considered with the aim of obtaining a procedure which is suitable for computers. This is especially the case for the second method discussed, which operates with hyper-matrices, the elements of which are matrices of order 2. Both methods are based on the fact that the field of complex numbers $a + bi$ is iso-

morphic with the field of matrices of order 2 of the form $\begin{bmatrix} a & -b \\ b & a \end{bmatrix}$. It appears that in this way a satisfactory solution can be given using further only well-known principles of linear algebra.

A. van Heemert, Netherlands

1672. Greenspan, D., On a "best" five-point difference analogue of Laplace's equation, *J. Franklin Inst.* **266,** 1, 39–46, July 1958.

After defining the phrase "allowable difference analogue" and "best difference analogue of Laplace's equation," author proceeds to prove the following result. The "best" five-point difference analogue of $u_{xx} + u_{yy} = 0$, when the grid sizes are not necessarily the same, is the difference equation: $-4u_0 + 2(u_1 + u_3)/(1 + p^2) + 2p^2(u_2 + u_4)/(1 + p^2) = 0$, where p is a positive constant.

E. J. Scott, USA

1673. Shaffer, B. W., and Krause, I., Method of finite differences, *Prod. Engng.* **29,** 42, 77–79, Oct. 1958.

1674. Todorow, M., Iterative treatment of linear systems of equations (in German), *Bautechnik* **35,** 4, 136–138, Apr. 1958.

The total step iteration method for linear algebraic systems can be written

$$x^{(n+1)} = B\,x^{(n)} + y$$

Paper introduces variation by adding $\alpha^{(n)}Be$ to right-hand side where e is a column matrix every element of which is unity and $\alpha^{(n)}$ is a parameter obtained by minimizing the square of $x^{(n+1)} - x^{(n)} - \alpha^{(n)}e$. The motivation for the choice of e or the criterion for $\alpha^{(n)}$ is not clear. Procedure is organized efficiently for desk calculator. Numerical examples show increased speed of convergence. For some systems convergence occurs for new procedure when old procedure diverges; for other systems converse is true. A similar variation for the Gauss-Seidel iteration is also proposed.

S. H. Crandall, USA

1675. Forsythe, G. E., Singularity and near singularity in numerical analysis, *Amer. Math. Monthly* **65,** 4, 229–240, Apr. 1958.

In a number of areas of mathematics there is one formula for the "regular" case, and a different formula or technique for the "singular" case. Author feels that, from the common-sense standpoint of computing, such a sharp dichotomy is unlikely to make sense; there must be an important transition zone of the "nearly singular." The nearly singular case often cannot be solved accurately with the "regular" method. A sufficiently accurate treatment of the nearly singular problems may be presented in one of two ways: (1) by simply applying the method for a close-by singular problem, accepting the error caused by the change of the problem, or (2) by recasting the method for the regular case in which the solution converges to the method for the singular case, as the problem becomes singular. Examples of both cases are given.

M. L. Pei, USA

Book—1676. Alt, F. L., Electronic digital computers—their use in science and engineering (Applied Mathematics and Mechanics Series, Vol. 4), New York, Academic Press, Inc., 1958, x + 336 pp. $10.

Book is intended as an introduction to the field of electronic computation. The four main parts deal with: computer components and their functions; programming and coding; problem analysis; and survey of computer applications. In the reviewer's opinion, it has an advantage over other recent books on the subject in that the treatment is general, encompassing a variety of machines and methods, rather than centered around the order code of a particular machine. As a matter of fact, actual machine instructions are confined to two chapters. Thus a clear picture of fundamental concepts is presented.

The description of machine components, their function and physical realization is thoroughly covered. Coding is demonstrated for a four-address and a single-address machine and the relative merits discussed. The basic aspects of programming are discussed, although little is said about the programming of logical manipulation and decisions. Similarly, machine aids, especially automatic programming, are only briefly covered.

The discussion of problem analysis covers: evaluation of explicit functions; differentiation, integration and interpolation; solution of ordinary and partial differential equations; solution of linear and nonlinear equations; and other related topics. In most cases, several alternate methods are described and their suitability evaluated in terms of ease of checking errors, stability, programming and computing time and storage and output requirements. There is considerable emphasis on specific requirements for tabulating large quantities of computed data.

The survey of problems solved by computers, although sketchy in some areas, is interesting reading. The general description of computation laboratories is valuable, but more could be said about the use of programs or subroutines available from program libraries or users' associations.

S. J. Fenves, USA

1677. Harrison, J. M., The digital computer as a helicopter flight simulator, *J. Helicop. Assn.* **12,** 2, 41–65, Apr. 1958.

1678. System design of digital computers at the National Bureau of Standards: methods for high-speed addition and multiplication, *Nat. Bur. Stands. Circ.* 591, 22 pp., Feb. 1958.

1679. Diamantides, N. D., A pilot analog for airplane pitch control, *J. Aero. Sci.* **25,** 6, 361–370, June 1958.

Author has developed an analog computer simulating an average pilot's dynamics in response to a disturbance in airplane pitch. Physiological factors which affect the human as a controller are considered in the synthetic (trial and error) development of the analogous circuit. The criterion of success is that jet pilots failed to detect immediately the substitution of the analog pilot for themselves in a control loop. Author details the mathematics of his system and presents an over-all pilot equation. Also included are circuit diagrams and data comparing jet pilot versus analog response.

An important observation is that differences in response between pilots could be measured accurately with reference to the average pilot simulator; thus this kind of computer permits measurement of human characteristics and can serve as a tool in human dynamics research.

J. W. Hlinka, USA

1680. Ernst, D., Arrangement and working principle of electronic analogue computers. Part I (in German), *Regelungstech.* **6,** 4, 125–128, 1958.

1681. Ernst, D., Arrangement and working principle of electronic analogue computers. Part II, (in German), *Regelungstech.* **6,** 5, 162–167, 1958.

1682. Vitenberg, I. M., and Gluzberg, E. A., Solving boundary problems, algebraic, transcendental and integral equations by means of analog computers (in Russian), *Avtomatika i Telemekhanika* **17,** 7, 590–600, July 1956.

Book—1683. Susskind, A. K., editor, Notes on analog-digital conversion techniques, New York, John Wiley & Sons, Inc., 1957, x + 410 pp. $10.

The present growing use of digital computers for data reduction and for automatic control makes analog-digital conversion an important subject. The different aspects of subject are treated in the book by different specialists. The problems encountered when converting from continuous signals to discrete data are briefly but

thoroughly discussed and some common pitfalls pointed out. Digital codes, digital circuits, and coding and decoding techniques are given detailed discussion and form the main part. Application of the technique is illustrated by description of an actual digital instrumentation system.

Book certainly fills a need for a unified treatment in one volume of this diverse subject. It is well planned and clearly presented and should be a valuable aid for all those working in this or in related fields. B. Langefors, Sweden

Book—1684. Booth, Kathleen H. V., Programming for an automatic digital calculator, New York, Academic Press, Inc., 1958, vii + 238 pp. $7.50.

This book gives a handy account of some of the routines used on APEXC, the electronic computer at Birkbeck College, London. After introduction on the machine, and some elementary illustrations of programming techniques, details of input and output routines are presented. Then chapters on division and square root, miscellaneous subroutines (polynomial, inverse cosine, integration, etc.), non-arithmetic programs (normalize, max, meshing, etc.), matrix operations (matrix multiplication, iterative method of evaluating the largest latent root), and simultaneous linear equations follow. Such topics as mechanical translation, an interpretive program for decimal tapes, and pseudo-codes for floating point arithmetic are also dealt with. The last chapter treats the important subject of fault finding and includes some comments on automatic programming.

Reviewer comments that publication, such as this, of library routines actually in use at an operating computation laboratory is highly welcome.

For a beginner, the simple order code, with only 15 orders, is easy to learn, and, if he only spends enough time on earlier chapters (up to Chapter 4, say), apparent complexity of the programs will not block him thereafter.

It is to be hoped that some existing errors will be corrected in future editions. S. Moriguti, Japan

Book—1685. Booth, A. D., Brandwood, L., and Cleave, J. P., Mechanical resolution of linguistic problems, New York, Academic Press, Inc., 1958, vii + 306 pp. $9.80.

Book contains an account of some of the results which have been obtained on the application of digital calculators to linguistic problems. It gives actual details of the translating techniques achieved with the APEXC computer. Ed.

1686. Kaufmann, H., Data processing systems, their language and their operation (in German), *Regelungstech.* **6,** 6, 219–223, 1958.

General discussions on analog and digital computers are given describing their costs, accuracy, tasks and operation. Also the languages or codes and memory capacity are discussed briefly.
M. Sanuki, Japan

1687. Levens, A. S., The transformation of families of data curves to alignment nomograms, with applications to stress data, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 97–106, 1958.

Article describes transformation of concurrency nomograms to alignment nomograms by applying the "law of duality" and applies the method to families of curves. Method is useful with experimental data for which an empirical equation is not known or needed.

Alignment charts are constructed for four examples involving stress analysis. Such charts should be useful for design purposes.
W. B. Stiles, USA

Analogies

(See Revs. 1672, 2070)

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 1719, 1723, 1775, 1802, 2110)

Book—1688. Seely, F. B., Ensign, N. E., and Jones, P. G., Analytical mechanics for engineers, 5th ed., New York, John Wiley and Sons, Inc., 1958, xvi + 475 pp. $7.25.

[See AMR **5** (1952), Rev. 2264]

This text is one of a class which may be considered as conventional in undergraduate engineering education in the USA today. First published in 1921 it has now appeared in a 5th edition. Since it is completely representative of texts that are so widely used, it should be of some concern to teachers and to research workers in the field of applied mechanics and engineering to determine whether this text, and others like it, are really suitable ones for use in a first course in undergraduate mechanics for engineers.

At the present time the emphasis on fundamentals is more important than ever as curricula are becoming both more crowded and advanced scientifically. It is of the utmost importance that the basic courses, such as one in mechanics, be presented adequately so that future courses, including graduate courses, can be built upon a sound foundation. The emphasis at the level of a first course normally offered at the sophomore year should be upon reasonable generality and a sound appreciation of the relationship between mathematics and physics and their applications to problems in mechanics. The fundamentals should be stressed and presented clearly. It is true that these requirements may well be interpreted differently by different authors but in the reviewer's opinion this text has serious defects.

First let it be said that it is a book which has been painstakingly assembled and modified over the years. The authors have evidently worked industriously to make this text an outstanding representative of its class. However, in the reviewer's opinion this has not produced a text which is suitable for the presentation of the fundamentals.

A text on the fundamentals of mechanics should at least have some comments on the historical development of the subject, and, for future reference, a readable and concise presentation of the basic theorems and methods. This text has little or no material on the historical development and the general treatment is pedestrian throughout. Less than half of the book is text material so that the student can scarcely have any feeling of continuity in reading it. In its 475 pages are 569 figures and 905 numbered (and 143 review) problems—a typical distribution in such texts and one which has been determined upon, presumably, as a convenience to the teacher and as an aid to the student. But it is questionable to have any discussion of basic matters hopelessly broken up by endless series of more or less identical and routine problems; a sound treatment of mechanics at this level does not, in the reviewer's opinion, require any such drawn-out presentation. Perhaps 250 pages would suffice, but 475 pages are surely too many; it is regrettable that the same tendencies are also evident in corresponding texts in the calculus. Our students cannot be held at fault in the lack of grounding in fundamentals if it is so difficult to find the statements in the texts they are reading; the situation is worse when they are required to review the fundamentals in later courses. Endless particular cases are treated in such piecemeal fashion that a real mastery of this basic subject would be very difficult to obtain with a text such as this, or one very similar to it.

The Preface lists 11 areas in which changes have been made from former editions. For example (p. vi, 1) it is stated that a general coplanar force system is to be used in the subsequent presentation and that special cases would be drived from it; this would certainly be a sound procedure. Yet the actual treatment

(p. 34 ff) hardly starts from this general standpoint; for example, by writing down the analytical conditions for the general case. It is stated explicitly (p. 3) that the use of "analytical" in the title will be synonymous with "mathematical methods," yet the development of the text does not follow these lines. So many qualifying statements are made that the student can scarcely see the general principles. The fact, for example, that a couple can be represented by a vector is merely stated (p. 23) without real justification. The treatment, on the whole, is not clear or convincing. Only later (p. 75, 118) are the general equations stated.

On page vi,4 it is also stated that, because of its growing importance in engineering applications, a section on fluid friction has been added; since this material is all of 2 pages and is entirely perfunctory in nature, its value is questionable.

No direct use of vector algebra and calculus, even in the most elementary form, is used in the main body of the text; however a short and inadequate sketch is given in a chapter under Special Topics. A vector presentation is no longer a luxury and it is time to take this material and use it in the text itself, where it properly belongs. For example in chapter 8 on "Kinematics of a particle" there would have been every reason to present the subject in vector form. The present treatment, as a result of this omission, is hardly clear or concise. The basic theorem (p. 224) on plane motion is stated and illustrated but not demonstrated; a good treatment would have been a simple matter in vector notation.

All too frequently elementary texts become cloudy when fundamentals are stressed; for example, on page 244 it is asserted without justification or explanation that $F = kd(mv)/dt$ holds for variable mass, and a variable mass system (rocket) is used in an example. No mention is made of any comparable statement for the case of rotation, which is surely also of importance in rocket flight. It is not to be expected that the text would specialize in rocket mechanics yet here was an opportunity to stress and to refine notions about fundamentals, even it if were not possible to go into lengthy discussions.

The text asserts that mathematical methods will be employed, yet when the differential equation $d^2x/dt^2 = -(kg/W)x$ arises, its solution is again given in a later chapter under Special Topics and no effort has been made to relate mathematics and physics into a coherent explanation. The period of vibration is given but this is little better than handbook knowledge at this stage.

The proof for the motion of the mass-center (p. 264–266) would probably repel a student; a clear and convincing proof could easily have been given in vector notation.

In the work on kinetics, useful results are stated but the general treatment does not come until later and it is presented in the usual fine print with particular results in bold face type. As is customary, an inordinate amount of attention is paid to methods which supposedly give the student practical mastery of the subject but which are not very likely to increase his understanding. In the reviewer's experience the excessive concentration upon "reversed effective forces" does not contribute much to the student's understanding either of fundamentals or of problems.

In chapter 17 on the "Introduction to mechanical vibrations (Special Topics)," an inadequate introduction is given with no clear discussion of the case of resonance even in the simplest case—surely another good opportunity to relate mathematics, physics, and mechanics. Although it is perhaps a small matter to mention, still when the authors refer (in italics) to a *complimentary* solution and repeat the word on the same page (423) and in the Index, the reader may be excused if he concludes that not enough care has been taken with regard to mathematical terms and methods.

Whether texts such as this, or similar ones, are the best to use should be examined carefully by all who have an interest in the preparation of students in the basic science of mechanics.

F. V. Pohle, USA

1689. Chikin, V. A., Stability of permanent semi-symmetrical axes of a heavy solid body having an immovable point (in Russian), *Trudi Tyazansk. Radiotekhn. In-ta* **1**, 222–232, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5175.

Author utilizes the requisite conditions obtained by Grammel for the stability of the permanent rotation of a heavy solid body with one immovable point to investigate the stability of such rotation in the particular case when the center of gravity of the body is situated on the principal axis of inertia. In the general case adequate conditions for the stability of permanent rotation of a heavy solid body are given by V. V. Rumyantsev.

G. K. Pozharitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1690. Kostitsyn, V. T., A graphical solution of the problem of the motion of a body of variable mass (in Russian), *Trudi In-ta Mashinoved. Akad. Nauk SSSR* **15**, 60, 45–51, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6290.

The problem is investigated of determining the law of motion of a body of varying mass rotating about a stationary axis, on the assumption that the moment of inertia as a function of the angle of rotation, $I = I(\phi)$, and the torsional moment as a function of time, $M = M(t)$, are graphically determined. The starting equation has the form $d/dt\,(I\omega) = M$, representing a generalized Meshtchersky equation for the case when the absolute velocities of the added and subtracted mass particles are equal to zero.

The law of motion, $\phi = \phi(t)$, is determined graphically.

A. I. Zenkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1691. Mahalingam, S., A note on one-term approximate solutions for non-linear vibration problems, *J. Roy. Aero. Soc.* **62**, 570, 450–451 (Tech. Note), June 1958.

Author discusses one-term approximate solution of $\ddot{x} + \omega^2 x + \alpha f(x) = P \cos pt$. If $\alpha = 0$, $x = a \cos pt$ is a solution with $\omega^2 a = P + p^2 a$. Author suggests relationship between frequency ω_a and amplitude a_1 to be of form $\omega^2_{a_1} = P + p^2 a_1$ for $\alpha \neq 0$. A further relation between a_1 and $\omega^2_{a_1}$ is obtained from a one-term approximate solution of the force free equation, $P = 0$, such as obtained by Brook's iteration method or Duffing's one-term approximation method. A determination of amplitude a_1 is obtained, with $x = a_1 \cos pt$. Author quotes experimental and other evidence as proof that this novel method is highly accurate.

H. Lass, USA

1692. Harvey, T. J., Natural forcing functions in nonlinear systems, *J. Appl. Mech.* **25**, 3, 352–356, Sept. 1958.

The response of the general linear or nonlinear second-order system without damping is considered for a "natural" forcing function. The natural forcing function is defined as δ times the restoring function. It is shown that δ is a function of the ratio of the period of free oscillation to the period of the forcing function. In most frequency response considerations the forcing function is sinusoidal. It is shown that by using a "natural" forcing function the response in general is easier to obtain.

V. B. Haas, Jr., USA

1693. Ludwig, R., Influence of small changes of coefficients of a differential equation for a vibrating system upon the damping and frequency (in German), *ZAMM* **38**, 3/4, 160–162, Mar./Apr. 1958.

A convenient matrix method is presented for the title problem, taking into account first-order terms. Application to longitudinal stability of a sailplane is given. H. Parkus, Austria

1694. Miller, P. H., Jr., Hamilton's principle as a computational device, *Amer. J. Phys.* **25,** 1, 30–32, Jan. 1957.

The use of Hamilton's principle for finding the period of motion is discussed; examples shown include the simple pendulum, the motion of a bead sliding along a parabolic wire, and planetary motion. S. Fujii, Japan

1695. Akashi, H., and Levy, S., The motion of an electric bell, *Amer. Math. Monthly* **65,** 4, 255–259, Apr. 1958.

Authors treat the motion of the clapper of an ordinary electric bell, given by the differential equation $m\ddot{x} + kx = 0$ or F of harmonic motion. First they change this equation into a nondimensional form by introducing, among other things, a new variable $u = kx/F$. The solutions in the (u', u)-plane (u' = differential with respect to nondimensional time coordinate) are circles which are trajectories of the motion. These give a very clear picture of the motion of an electric bell in the (u', u)-plane. Finally, some examples are given which illustrate the forming of a limit cycle. The article shows the advantages of the use of phase plane in solving differential equations. E. Niskanen, Finland

1696. Bolotin, V. V., Interaction of forces and parametrically excited vibrations (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 3–15, Apr. 1956.

In recent days the problems of dynamical stability of elastic systems are of great interest because they are very much treated in linear and also in nonlinear theory. This paper is also devoted to this problem, and represents a systematic examination of interaction of forces and parametrically excited vibrations. Two cases are analyzed: (1) the vibrations of straight bar subjected to the action of an axial compressive disturbing force, and (2) the vibrations of symmetrically loaded arcs.

In the first case it is shown that when the axial force has the form $P(t) = P_0 + P_t \cos \theta t$ then the governed equation reduces to Mathieu's differential equation. The approximative Galerkin method is used and the stability regions are plotted. The effect of "transverse damping" is considered also. The phenomenon of "parametric resonance" (when $\theta \sim 2\omega$) is discussed.

The experimental investigations for the second case are presented and the obtained results are discussed.

D. Raskovic, Yugoslavia

1697. Kobrinskii, A. E., Vibrations in a two-body system moving with intermittent collisions (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 113–121, May 1956.

Author considers the problem of the free and forced vibrations of the system with two masses under nonlinear regime of motion. The characteristics of the eigenfrequencies are expressed as the functions of the parameters of the system and of the intensity of the initial perturbation. D. Raskovic, Yugoslavia

1698. Vorontsev, G. V., The problem of determining the influence of special loads on the magnitude of the deformations produced by ordinary loads (in Russian), *Nauch. Tr. Novocherkassk. Politekhn. In-ta* **29,** 43, 103–117, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7150.

Paper deals with the qualitative analysis of the influence of an extraordinary load N on the change in the magnitude of the generalized coordinate of a system a resulting from the application of an ordinary load P. Regarding an elastic structure first as a mechanical system with a finite, and secondly as one with an infinite number of degrees of freedom, author, applying the method of independently acting forces, demonstrates that in the case of $N \leqslant N_*$ (where N_* is the critical value) the curve of the functions of $1/a = f(N)$ will be convex. For the case when $N = f(P)$, the above derivation can be related to the curve of $P/a = f(N)$. It is demonstrated that if for $N = 0$ the deformation function f of any system can be represented by a particular expansion $f = c_1 f_1 + c_2 f_2 + c_3 f_3 + \ldots$, where $f_1, f_2, \ldots$ are principal coordinate functions, the action of extraordinary forces will be represented by the expansion

$$f = \sum_{i=1}^{\infty} C_i \frac{1}{1 - N/N_i} f_i \quad (N_i - \text{Euler forces})$$

In conclusion, the problem is examined of the forced vibrations of the structure under the action of loads of the form $P_0/\cos \omega t$. Introducing a corresponding generalized coordinate a such that the function of force $U = P_0 \cos \omega t$, author shows that $P_0/a = \psi(N, \omega^2)$ for $\omega \leqslant \lambda_1$ (λ = fundamental frequency of free oscillation of the structure when $N = 0$), and $N \leqslant N_*$ is the expression of a convex surface in the axes P_0, N, ω^2. N. N. Vorob'ev

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Instrumentation and Automatic Control

(See also Revs. 1663, 1679, 1685, 1963, 1974)

1699. Lehnigk, S., The time behavior of a linear control loop with periodic sensing device (in German), *Regelungstech.* **5,** 8, 271–273, 1957.

The characteristic response without disturbance of a linear control loop with a periodic sampling feedback device is analyzed. The stability criterion for such control systems is discussed and the possible existence of stable regions among the transfer functions of process and feedback controller, and also the impulse period of sampling device, is suggested. Special attention is called to the dependency of stability upon the impulse period of the sampling device, and an example is presented numerically together with its root-locus curve. Finally the effect of disturbance is briefly discussed. M. Sanuki, Japan

1700. Kuzovskov, N. T., Evaluation of the accumulation of deflections in linear systems by the method of logarithmic frequency characteristics (in Russian), *Vestnik Mosk. In-ta* no. 1, 33–39, 1956; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7533.

Author describes the method of evaluation of an accumulation of deflections in linear systems with the aid of logarithmic frequency characteristics. As an example the case of a single-axis gyroscopic stabilizer is examined, the stabilizer being under the influence of exciting moments. A graphical method to ascertain the maximum possible deflection for any t is indicated.

E. N. Miroslavlev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1701. Abdullaev, A. A., and Nadzhafov, E. M., Method of calculation of auto-oscillations in pneumatic regulators (in Russian), *Avtomatika i Telemekhanika* **17,** 3, 195–210, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5205.

The study is devoted to the investigation of auto-oscillations which appear in the inner surface of a typical industrial pneumatic regulator (type 04 of the factory "Tizpribor"). The inside contour of this regulator is represented by a closed dynamic chain, consisting of two nonlinear members with unsymmetrical fragmentarily broken three-link parts and of the linear members separating them. Different simplified models are discussed, permitting the computation by the method of harmonic balance of the auto-oscillations arising in a complicated system of this nature. Regions are established for the rational utilization of each of these rated models. The results obtained from the use of the rated models are compared with the experimental results previously published by the same authors. M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1702. Kuzovkov, N. T., Logarithmic frequency characteristics used as a method of plotting stability zones and equal damping lines (in Russian), *Avtomatika i Telemekhanika* **17**, 2, 173-179, Feb. 1956.

Author suggests method for treating parametric transfer functions, called "D-division method." Poles and zeros of the transfer function are determined by solving the equations of numerator and denominator after the parameter and treating the resulting function of the frequency ω by constructing its Bode diagrams (log · amplitude and phase versus ω), using the well-known curves for elementary functions. From the Bode diagrams ω is solved to obtain the polar plot of the parameter curve in the complex plane. An extension is given for functions of two parameters. The curves divide the complex plane into stable and unstable regions.

Lines of equal damping are obtained in the same way by substituting in the transfer function the complex frequency $-\delta + j\omega$ instead of $j\omega_1$ in which δ is the measure for the damping.

Method is complementary to the "root-locus" method and may be practical for certain problems. R. G. Boiten, Holland

Book—1703. Ku, Y. H., Analysis and control of nonlinear systems, New York, Ronald Press Company, 1958, vii + 360 pp. $10.

Book is intended primarily for engineers; numerical examples and graphical methods are predominant in the text; the use of quantitative methods is also indicated in connection with examples. Author's own acceleration-plane method plays a prominent role in the book, with numerous diagrams illustrating its various applications.

Book covers a considerable number of topics; perhaps too many for a book of 360 pp., a considerable part of which is occupied by nearly 180 figures. Referring more specifically to the contents, chapter 1 may be regarded as a summary of the existing methods, both graphical and analytical; the following chapter deals with standard linear problems. The nonlinear ones are treated in chapters 3 and 4; here again the graphical methods are used extensively; however, in numerical examples references appear to singular points; the latter are treated more systematically in chapter 5.

In chapter 6 are studied self-excited oscillations; once again the acceleration-plane method is used extensively; one feels that in this chapter the theory of limit cycles should be added, at least in its physical aspects but, for one reason or another, this subject is hardly mentioned. Chapters 7 and 8 are devoted to the nonautonomous systems; in chapter 8 is outlined the theory of the subharmonic resonance, mostly in connection with the existence of subharmonic solutions, but the question of their stability is mentioned but slightly.

The last chapters, beginning with chapter 9, relate to higher-order nonlinear systems as well as their control features. Here the mathematical fundamentals are far less advanced and for that reason author is obliged to make use of computing machines to check his results.

A book of this nature is certainly most welcome to those whose interests lie primarily in applications. Perhaps it is not an exaggeration to say that during the post two decades or so the nonlinear problems became practically a monopoly of mathematicians, which inevitably transfers them to a somewhat abstract level frequently inaccessible to engineers unless they wish to go through a rather elaborate gradual training in the theory of differential equations.

However, it is also inevitable that the present book with its opposite tendency oversimplifies somewhat the subject and directs too much attention to numerical calculations and graphical methods, leaving the theory somewhat in background, particularly its qualitative (topological) aspects. Thus, for instance, for a given differential equation and assuming some initial conditions, author traces out one single trajectory by his graphical method. In many cases this is probably a proper way of doing, but in such a case one is never certain about the totality of solutions or "the phase portrait" of the problem; very often there is danger of striking special situations involving "branch points," complicated conditions of equilibrium, etc., when a little change somewhere in the form of the differential equation may upset radically the whole picture. The nonlinear problems are particularly difficult because of the existence of such "critical thresholds."

Book should be a useful tool for those who are familiar with these topological aspects of nonlinear problems and wish to acquire a practice in numerical methods, but it is doubtful that it can be used by those who are entirely unfamiliar with the subject.

N. Minorsky, France

1704. Hopkin, A. M., and Ogata, K., An analytic frequency-response solution for a higher order servomechanism with a nonlinear control element, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-35, 5 pp.

Purpose of paper is to analyze the behavior of a closed loop system comprising an ideal relay and a general lumped-constant linear feed forward element. Piecewise linear differential equations are integrated with consideration of boundary conditions by Laplace transform methods. "Jump resonance" is found for two frequencies that are characteristic of the response to sinusoidal input.

Reviewer believes this approach is new. When usable it gives a better approximation than simple "describing function" method can yield. However, there seems to be no close relationship between the computations that are developed and the existence of subharmonics that are mentioned at the beginning of the paper.

J. M. Loeb, France

1705. Ogata, K., Subharmonic oscillations of non-linear feedback control systems, ASME Instruments and Regulators Conf., Newark, Del., Apr. 1958. Pap. 58-IRD-7, 6 pp.

Paper deals with subharmonics in a feedback system containing different kinds of nonlinearities.

First part of paper is devoted to an elementary demonstration of the obvious fact that if the nonlinearity is skew symmetric, only odd-order subharmonics can occur.

Since excitation of the subharmonic oscillations is hard, the problem of the necessary strength of the disturbance is studied in different cases by means of an analog computer. Examples of closed loop response curve for different orders of subharmonic oscillations, as well as cases of jump resonance, are exhibited.

G. Evangelisti, Italy

1706. Aizerman, M. A., and Smirnova, I. M., Application of the methods of the small parameter for the investigation of periodic regimes in systems of automatic control, not containing a small parameter (in Russian), Pamyati Aleksandra, Aleksandrovicha Andronova, Moscow, Izd-vo Akad. Nauk SSR, 1955, 77-92; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5181.

Methods are considered for the approximate determination of periodic regimes in nonlinear systems of automatic control. Discussions proceed in regard to methods which originate from the assumption of the proximity of these regimes to harmonic oscillations. Two hypotheses (the hypothesis of autoresonance and the hypothesis of the filter) are investigated, permitting the substantiation of approximate methods. Methods are put forward for the solution of problems on the search for and of problems on the stability of periodic regimes, based on these hypotheses. In the case of autoresonance the authors are of the view that the approximate methods on the search for periodic movements and also the methods of investigation of the stability of the regimes offer sufficient substantiation. In the case of the filter, formal proof is only available for the use of the assumption regarding the small difference between the periodic region and the harmonic oscillation. However, the article shows that here also in a series of cases (odd,

simple number nonlinearity of (x)) good results are obtainable by the "unorthodox" application of methods, entailing the acceptance of the assumption in systems with small parameters of the presence of the generated frequency of the approximate system.

N. N. Krasovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1707. Schafer, O., Three-point I-controller operating in accordance with a predetermined program (in German), *Regelungstech.* **6,** 5, 174-177, 1958.

Author extends the work of the reviewer on optimum nonlinear control where a controller terminates in a servomotor whose speed is constant except when at rest. The describing function is employed to analyze the response of systems for which the control function is a linear combination of the error and the absquare of the derivative of the error. The results are compared with the case where the absquare in this control function is replaced by a term proportional to the derivative of the error so that the control function becomes linear. The dependence of system performance on a parameter in the control function is brought out with the aid of curves representing the describing function.

In the opinion of reviewer, the engineer concerned with the design and analysis of nonlinear controls should find this paper very helpful. R. Oldenburger, USA

1708. Ivakhenko, O. G., Application of the conditions of the invariant in feeble nonlinear systems of automatic control (in Russian), *Dopovodl Akad. Nauk URSR* no. 1, 20-24, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5207.

1709. Rubin, S. B., Estimation of the influence of nonlinearity in the investigation of the transitional process for the simplest case of a pneumatic system (in Russian), Tochnost Izgotovleniya Sharikovykh i Rolikovykh Podshipnikov na Avtomat. Liniyakh, Moscow, Akad. Nauk SSSR, 1955, 182-188; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5209.

1710. Tsypkin, Ia. Z., Calculation of transients in nonlinear control systems (in Russian), *Avtomatika i Telemekhanika* **17,** 6, 500-512, June 1956.

1711. Kazakevich, V. V., Interrelation between the phase planes of Rayleigh's equation and van der Pohl's equation (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **107,** 4, 521-523, Apr. 1956.

1712. Goodman, T. P., and Hillsley, R. H., Continuous measurement of characteristics of systems with random inputs: A step toward self-optimizing control, ASME Instruments and Regulators Conf., Newark, Del., Apr. 1958. Pap. 58-IRD-5, 9 pp.

To achieve self-optimizing control, a signal which reflects changes in system dynamics must be available to actuate controller adjustments. In this paper a new technique is presented whereby changes in system parameters are detected from changes in the moments of the system impulse response. At the same time, changes in input statistical properties are detected by changes in the moments of the input autocorrelation function. Recent investigations by Paynter and others have shown the importance of impulse-response moments as a means for characterizing the dynamics of a system. By the technique described in this paper, these moments are determined continuously and directly from the random variations in the system input and output, without passing through the intermediate steps of obtaining the input-output correlation functions and the system's impulse or frequency response. The precision of measurement of the moments can be estimated statistically, so that the design specifications for the equipment required for any desired precision of measurement can be established. The new technique has been applied experimentally to a simple linear system with promising results.

From authors' summary by M. Shinbrot, USA

Book—1713. Gibson, J. E., and Tuteur, F. B., Control system components, New York, McGraw-Hill Book Co., Inc., 1958, ix + 493. $12.

The text provides an introductory treatment of a number of the most commonly used components in servomechanisms and other feedback control systems. Coverage includes electrical networks and amplifiers, electrical machines, modulators and demodulators, gearing, mechanical networks, hydraulic machines and pneumatic components.

Over-all impression is that the discussion is elementary and does not delve too deeply into more advanced analytical considerations. Material on design procedures would have enhanced the work. L. A. Gould, USA

1714. Trapeznikov, V. A., and Kogan, B. Ya., Modern methods of experimental investigations of automatic control systems (in Russian), Trudi 2-go Vses. Soveshchaniya po Teorii Avtomat. Regulirovaniya, Vol. 3, Moscow-Leningrad, 1955, 7-36; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7561.

The essence of the method of natural investigations is put forward, as are also the physical and mathematical miniature scale operations, for systems of automatic control. Schematic plans are given with descriptions of various electronic and electromechanical elements of contemporary mathematical models (calculating parts, functional transformers, multiplying and dividing devices, etc.). Briefly described are the principles of construction of mathematical models, while mention is made of the models issued by Soviet industry at this time, and also of models designed in the Institute of Automatics and Telemechanics of the Akademiia Nauk SSSR. Photographs are given of the exterior views of models of types IPT-4, IPT-5, MPT-9, EMU-2, EMU-3, EMU-4. The fact is emphasized of the necessity to develop methods of electronic mathematical modelling. E. P. Popov

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1715. Kosharskii, B. D., Some problems of calculation for hydraulic jet boosters (in Russian), *Avtomatika i Telemekhanika* **17,** 7, 611-619, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5579.

Hydrodynamic phenomena are investigated in boosters of the jet or jet-valve type. Relations are given, experimental and theoretical, between the delivery, pressure and velocity of the working agent in jet boosters. A calculation is given for the hydraulic boosters examined.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1716. Vorovish, I. I., Steady motion in the presence of accidental perturbations (in Russian), *Izv. Akad. Nauk SSSR Ser. Matem.* **20,** 1, 17-32, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2668.

1717. Simkin, M. M., Application of digital computers in automatic control systems (in Russian), *Avtomatika i Telemekhanika* **17,** 2, 180-190, Feb. 1956.

1718. Opfell, J. B., and Sage, B. H., Applications of least squares methods, *Indust. Engng. Chem.* **50,** 5, 803-806, May 1958.

1719. Slomyanskii, G. A., Shortened equations for the motion of a rapidly rotating gyroscope in Cardan suspension and the influence of static unbalance of the gyromotor on the behavior of the gyroscope (in Russian), *Trudi Mosk. Aviats. Tekhnol. In-ta* no. 27, 57-71, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5154.

Known shortened equations are established for a rapidly rotating gyroscope in Cardan suspension. Author formulates the principle of precession and shows that the solutions of the shortened equations lead easily to the quadratics, if the moments acting on the gyroscope depend only on one of the angles of rotation of the axis of the Cardan suspension. The influence is examined of the static unbalance of the gyromotor taking into account the forces of Coulomb friction on the motion of the gyroscope, and some deductions are made regarding the balancing of the system.

D. R. Merkin

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Tables, Charts, Dictionaries, etc.

(See Rev. 1685).

Elasticity

(See also Revs. 1751, 1754, 1774, 1782, 1808, 1844, 1874, 1894, 1895, 2132)

1720. Reiner, M., and Rintel, L., The complete stress-strain law in infinitesimal elasticity, *Bull. Res. Counc. Israel* **6C,** 2, 113–126, Feb. 1958.

This paper shows that, in infinitesimal strain, second-order effects will be present when there is rotation of the principal axes. For isotropic material, the stress s is expressed in terms of strain ε as

$$s_{lm} = (\lambda \mathrm{I} + \delta \mathrm{II})\,\delta_{lm} + 2\mu\,\varepsilon_{lm} + 4\mu_c\,\varepsilon_{l\alpha}\,\varepsilon_{\alpha m}$$

where I and II are the first and second strain invariants; λ and μ are Lame's constants. In addition to the two elastic constants λ and μ in the classical theory, δ the modulus of dilatancy and μ_c the modulus of cross-elasticity are required to give the complete stress-strain relation. T. H. Lin, USA

1721. Schleicher, F., Concerning the theorem of Mohr (in German), *Bauingenieur* **32,** 10, 369–377, Oct. 1957.

1722. Chattarji, P. P., Elastic distortion of a cylindrical hole by tangential tractions varying with depth on the inner boundary, *J. Technol.* **2,** 2, 141–144, Dec. 1957.

Elastic distortion of a cylindrical hole by localized hydrostatic pressure has been analyzed by H. M. Westergaard and C. J. Tranter and that by localized and uniform tangential tractions on the inner boundary by S. C. Das. Two other problems are mathematically solved in this paper: (1) Twisting of an infinite elastic plate having finite thickness with a cylindrical hole acted on by tangential traction throughout, varying linearly with depth, one face of the plate being fixed and the other free. (2) Both faces of the plate are supposed to be free, while the hole is acted on by tangential traction throughout, varying as the square of depth. Solutions in both cases are obtained in terms of infinite series.

J. J. Polivka, USA

1723. Brock, J. S. Analytical determination of the stresses around square holes with rounded corners, *David W. Taylor Model Basin Rep.* 1149, 29 pp., Nov. 1957.

For deriving the stress distribution around a square hole with rounded corners the complex-variable method of Muskhelishvili is used combined with conformal mapping functions corresponding to the Schwartz-Christoffel transformation.

H. Neuber, Germany

1724. Csonka, P., Contribution to the elastic theory of isotropic bodies (in English), *Acta Techn. Hung. Budapest* **17,** 3–4, 355–359, 1957.

Author examines what functional relations must hold between components of stress and strain assuming that direct stress components are functions *only* of direct strains and that shear stress components are functions *only* of shear strains.

D. M. A. Leggett, England

1725. Solyannik-Krassa, K. V., The deformation of bodies of rotation (in Russian), Avtoref. Diss. Dokt. Fiz.-matem. Nauk, Leningrad Polytechnic Inst., Leningrad, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6999.

1726. Sherman, D. I., Effective methods of integral equations and their application to some problems in the theory of elasticity (in Russian), Trudi 3-go Vses. Matem S'ezda., Vol. 1, Moscow, Akad. Nauk SSSR, 1956, p. 216; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5859.

1727. Khuberian, K. M., Force planes with given stress values under hydrostatic load (in Russian), *Issled. po Teorii Sooruzheniy.* no. 6. 347–355, 1954; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3412.

1728. Shelyongovski, F., A solution of the two-dimensional problem in the theory of elasticity in rectangular coordinates, in the presence of the action of mass forces (in Russian), *Byul. Polsk. Akad. Nauk, Otd.* (4) **4,** 2, 113–118, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7003.

The two-dimensional case of the theory of elasticity is examined for the case of an isotropic body acted upon by mass forces as well as superficial stresses. Author transforms the general equations of the two-dimensional problem by substituting for the derivatives according to x and y the derivatives of the complex variable $z = x + iy$ and $z_1 = x - iy$ and subsequent integration. As a result, expressions are obtained describing the stresses and displacements by two functions of the complex variable z and the projection of the mass forces, representing a generalization of the known formulas of Kolossov and Muskhelishvili for the case of the action of arbitrary mass forces. Expressions are also indicated for the stresses and displacements by two functions of the complex variable as well as two real harmonic functions for the case when the mass forces possess a potential. S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1729. Theodorescu, P. P., On a general solution of a three-dimensional problem in the theory of elasticity (in French), 9th Congrès Intern. Mécan. Appl., Bruxelles Univ. 1957; **5,** 155–167.

A general solution of the three-dimensional elasticity problem with zero body forces by means of three biharmonic stress functions is presented. The method should be more successful in the treatment of problems where the boundaries are planes parallel to the coordinate planes.

Using Almansi's theorem, expressions for the three biharmonic functions in terms of four harmonic functions (which can be reduced to three as shown by Papkovitch and Neuber) are also given.

Finally, expressions for the displacements in terms of the stress functions are also derived. These come out to be somewhat more complicated than those obtained by more direct approaches like, for instance, Galerkin's.

E. Saleme, Argentina

1730. Massonnet, Ch., General solution of the stress problem in three-dimensional elasticity (in French), 9th Congrès Intern. Mecan. Appl., Bruxelles Univ. 1957; **5,** 168–180.

Solution the three-dimensional elasticity problem of the first kind is obtained by an adequate distribution of elementary Kelvin singularities so chosen as to satisfy the boundary conditions.

The method leads to a vector integral equation of the second kind (equivalent to three scalar integral equations) which can be solved by successive approximations and, hence, should be suitable for electronic digital computer treatment.

E. Saleme, Argentina

1731. Panarin, N. Ia., The effect of heat waves on the stressed state of a rectangular slab, *Soviet Phys.-Tech. Phys.* **2,** 5, 1019–1022, Feb. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 1121–1124, May 1957 by Amer. Inst. Phys. Inc., New York, N. Y.)

Rectangular slab [illegible] initial temperature and with thermally insulated ends is i[illegible] in a medium whose temperature varies with time sinusoid[illegible] zero mean. Expressions are derived for the stresses (a[illegible] ly resting slab, (b) in a slab with edges held fixed.

G. Sved, South Australia

1732. Langer, B. F., Coffin, L. F., Jr., Blaser, R. U., and Cooper, W. E., Proceedings of a panel discussion on thermal stresses, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 115–147, 1958.

This panel discussion consists of three papers on the subject of thermal stresses in ductile metals: (1) "Thermal stress and thermal stress fatigue" in which the author, L. F. Coffin, Jr., points out the difference between conventional fatigue and thermal stress fatigue. In the former, stress is the independent variable, while in the latter, temperature and hence strain is the independent variable. The difference in these problems is significant in the low cycle fatigue range where failure results from thermal stresses well in excess of the yield strength of the material. Author reviews the experimental problem [AMR **7** (1954), Revs. 2481, 2482] which was used to determine several effects, such as temperature range, prior cold work, mean temperature and speed of cycling, on the fatigue process. He points out the existence of the following relation $N^{*}\Delta\varepsilon_p = C$, where $\Delta\varepsilon_p$ is the plastic strain range and N is the cycles to failure. Author also reviews briefly the problem of cyclic strain localization and its design implications.

(2) "Thermal stress problems in practice" in which the author, R. U. Blaser, gives many illustrative examples to show that thermal stresses can occur from temperature differences within a piece of material, from parts of an assembled structure at different temperature, or from combinations of materials having different thermal expansion characteristics. Also included is the effect of thermal stresses on mechanical joints such as gasketed joints and closures.

(3) "Design basis for thermal stresses" in which the author, W. E. Cooper, discusses the factors which must be considered as the basis for structural design. These are the operational conditions, stress and deformation analysis, design and fabrication details, design criteria. Author also discusses the problem of design criteria for thermal stresses. Factors to be considered here are cumulative damage role, criterion of failure under combined loading, and establishment of limits for thermal stress in practical design.

T. H. H. Pian, USA

1733. Tchetche, A. A., The calculation of concrete blocks and solid slabs on rigid and elastic foundations for temperature influences by the method of Prof. V. Z. Vlassov (in Russian), *Sb. Nauch. Rabot Beloruss. Politekhn. In-ta* no. 54, 139–155, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7046.

Solutions are given for some problems on the thermal stress condition of rectangular beams. Applying the method of variations and representing the displacements by finite series, the problem is reduced to the solution of a system of ordinary differential equations.

Calculation formulas are obtained for a thick slab on an elastic foundation acted upon by harmonically oscillating temperatures on the external surface of the slab.

M. A. Zadoyan

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1734. Derski, W., The state of stress in a thin circular ring, due to unsteady temperature (in English), *Arch. Mech. Stos.* **10,** 3, 255–270, 1958.

Author solves the thermoelastic problem for a thin circular ring in the case of axial symmetry, that is, he determines the temperature and the stresses. The agent provoking the phenomenon is a given temperature or its gradient at the edges r_1 and r_2 of the ring. The problem is solved for the most general boundary conditions depending on time according to Heaviside's function. In particular the known solution for a steady-state temperature distribution is obtained.

J. Mossakowski, Poland

1735. Endres, W., Thermal stresses in pipelines (in German), *Forsch. Geb. Ing.-Wes.* **23,** 1/2, 33–37, 1957.

The thermal stresses which arise in a curved piping system rigidly fastened at the ends depend upon several parameters. All variables present can be encompassed by two dimensionless indices. One indicates the degree of loading and the other represents the geometry of the pipe axis. If we consider piping systems of somewhat similar form, a relation between these two indices can be deduced. There exists an upper bound for this relation when we further consider piping systems of different form. This "upper-bound" relation can serve as a criterion telling us whether the loading of a specific piping system, under given conditions, is within allowable limits.

Author demonstrates his criterion with the aid of a number of specific cases of simple form. He also discusses the effect of "flattening of the cross section" (of thin tubes), and the limitations of the criterion. How the designer can use it is also briefly noted. Reviewer feels that criterion can be useful, especially in noncritical applications. However, complex systems or very "tight" design will require model analysis (suggested in paper) or detailed conventional calculations.

J. L. Lubkin, USA

1736. Ylinen, A., Influence of the summer wood content and specific gravity on the moduli of elasticity, Poisson's constants and the moduli of rigidity in wood with distinct annual growth rings (in German), Inst. of Tech., Helsinki, Scientific Research no. 9, 26 pp., 1956.

The moduli of elasticity in wood depend greatly on the relative portion of summer wood in the annual growth rings, on specific gravity, width of annual growth rings, moisture content and temperature. Usually wood is treated in the mathematical theory of elasticity as an anisotropic material having nine independent constants of elasticity, but author also considers the different values of the elastic constants in spring wood and summer wood, there being thus 18 independent constants. Expressions are derived for the ordinary moduli of elasticity (E_L, E_T, E_R), moduli of rigidity (G_{LT}, G_{TR}, G_{RL}) and Poisson's constants. From the expressions it appears how these constants depend on the corresponding constants of spring wood and summer wood, the relative portion of summer wood, and the specific gravities (average specific gravity of wood and specific gravities of spring wood and summer wood). Considering only decisive quantities, simple approximate expressions for the constants are obtained, the error being small, in all cases under 10%. Assuming that the equations corresponding to known equations $\nu_{TL}/E_T = \nu_{LT}/E_L$, etc., are true separately for spring wood and summer wood, it is shown that conditions $\nu_{TL}/E_T = \nu_{LT}/E_L$, etc., are true also for average elastic constants. The approximate expressions also satisfy these conditional equations.

The publication is a valuable addition to our knowledge of the dependence of nine average constants of elasticity on different factors.

E. Niskanen, Finland

1737. Johnson, K. L., The effect of spin upon the rolling motion of an elastic sphere on a plane, *J. Appl. Mech.* **25,** 3, 332–338, Sept. 1958.

The motion and deformation of an elastic sphere rolling without sliding in a straight line on an elastic plane have been studied theoretically and experimentally for the case when the sphere has an angular velocity about an axis through the point of contact normal to the plane. Surface tractions caused by this spin are found, which demonstrate the necessity of partial slip in the contact area. A system of surface tractions is found which corresponds to zero stress at the leading edge of the contact circle. This system of tractions gives rise to a transverse velocity (termed "creep") of the sphere in the direction of its spin. The magnitude of this creep is calculated for a small angular velocity of spin when the degree of slip is vanishingly small.

Author observed the effect mentioned casually by Palmgreen (1928), that in a simple thrust bearing with plane parallel races the balls did not move around a perfectly circular path but exhibited a creeping motion radially outward. Measurements of this radial creep have been made which agree with the theoretical approximate relationship.

Z. Horak, Czechoslovakia

1738. Aleksandrov, A. Ya., An approximate method for solving two-dimensional contact problems of the theory of elasticity (in Russian), *Trudi Novosibir. in-ta inzb. zh. -d. transp.* no. 11, 5–28, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4569.

A general method is described for solving two-dimensional contact problems for two elastic bodies or an elastic body and a perfectly rigid die, with complete cohesion, friction or free slipping between them. The elastic body, if it does not have a rectilinear boundary, is assumed to be a part of the whole plane. With a rectilinear boundary, the body is assumed to be a part of a semisurface, the boundary of which coincides with the rectilinear boundary of the body. In order for the stressed state of a part of a plane or semiplane to be identical to the stressed state of the body when fulfilling the contact conditions, specific vertical and horizontal loads are placed along the contour separating the body from the plane or semiplane. The law of distribution of these loads is given in the form of parabolas of degree n. The unknown coefficients in the parabola equations are determined from the requirement to fulfil contact conditions at a number of points on the line of contact. For the sake of simplicity the required loads are replaced by a system of concentrated forces. Then, for example, using the semiplane (the basic case examined in the paper) the stressed state is determined by summation of the stresses due to the separate forces, while the components of these stresses are determined from Melan's formulas [E. Melan, *ZAMM* **12**, no. 6, 1932]. The displacement formulas were obtained by the author by integrating Melan's stress formulas. The calculation is facilitated by the construction of lines of influence for displacements and stresses.

As an example a solution is given of the problem of driving a rigid wedge into a triangular notch near the boundary of the semiplane.

Author did not notice an error in Melan's formula for the horizontal component of normal stresses from loading by a horizontal force (in the case of a horizontal boundary of the semiplane). Therefore the displacement formulas derived from the action of this force are incorrect.

M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1739. Archibald, F. R., Designing interference fits, *Mach. Design* **30,** 22, 133–134, Oct. 1958.

Viscoelasticity

(See also Revs. 1796, 1849, 1852)

1740. Findley, W. N., Poczatek, J. J., and Mathur, P. N., Prediction of creep in bending from tension and compression-creep data when creep coefficients are unequal, *Trans. ASME* **80,** 6, 1294–1298, Aug. 1958.

It has been shown that creep and stress distribution in bending can be predicted from tension and compression-creep data. However, available test data are inadequate to provide an accurate check of the theory.

The theory showed that the stress distribution and position of the neutral axis in a beam changed with time when the creep in tension and compression were unequal. When the time-dependent and time-independent stress functions were unequal the stress distribution in a beam changed with time.

From authors' summary by K. Angervo, Finland

1741. Rozovsky, M. I., A semi-symbolic method of solving certain problems in the theory of creep (in Armenian), *Trudi Akad. Nauk ArmSSR, Otd. Fiz.-Mat., Estestv. Tekhn. Nauk* **9,** 5, 43–60, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7118.

A method of solution is proposed for the integral-differential equation

$$\frac{\partial^m \omega}{\partial x^m} + a^2(t)\omega = f(x,t) + \int_{\tau_1}^{t} k(t,\tau)\frac{\partial^m \omega(x,\tau)}{\partial x^m}\,d\tau$$

consisting in representing the solution by a generalized Neumann series obtained by expanding the solution according to symbolic powers of the operator k^*:

$$k^* y = \int_{\tau_1}^{t} k(t,\tau)y(\tau)d\tau.$$

It is demonstrated that on the condition of limiting $f(x,t)$, $k(t,\tau)$ and the initial values of the function ω and its derivatives in x up to the $m = 1$ order inclusively, the series converges, and does, in fact, furnish the solution. This method is applied to the problem of the longitudinal bending of a bar on the assumption that the stress σ and deformation ϵ are connected by Yu. N. Rabotnov's relationship. It is further proved that if the nucleus $k(t,\tau)$ is a differential nucleus with a weak singularity, this method can also be applied to the solution of the Cauchy problem for the equation of oscillation of an unlimited, residually elastic medium.

N. A. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1742. Weertman, J., High-temperature creep of metals, *Rep. NRL Progress* 15–20, Feb. 1958, (PB 131635).

Theoretical and experimental work at NRL on high-temperature creep of metals has revealed that at low stresses the steady-state creep rate obeys a power-law stress dependence. This dependence can be explained in terms of a dislocation creep model.

From author's summary

1743. Smith, G. V., Garofalo, F., Whitmore, R. W., and Burt, R. R., Creep-rupture strength of austenitic Cr-Ni-Mo steels in sheet and bar form, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-102, 7 pp.

Creep-rupture tests at 1100, 1300, and 1500 F on seven bar-stock and seven sheet-stock, 18 Cr-8 Ni-Mo steels show that small variations in *C*, *N*, and *P* measurably influence both 100 and 1000-hr creep-rupture strength. Variation in amounts of *C*, *N*, and *P* accounts for at least one third of the variability in creep-rupture strength. The additional variability may be related to differences

in thermal and mechanical history and in the inherent variability in creep-rupture testing. The bar-stock steels are slightly stronger at 1100, 1300, and 1500 F for rupture in 100 hr and at 1300 and 1500 F for rupture in 1000 hr. At 1100 F, essentially no difference is found between bar and sheet steels for the 1000-hr rupture strength. From authors' summary

1744. King, E. G., The strain behavior of wood in tension parallel to the grain, *Forest Prod. J.* **8,** 11, 330–334, Nov. 1958.

Short-term creep tests were performed on three U.S. and eight South American wood species covering the specific gravity range from 0.40 to 1.04.

The creep-stress level relation is described by a linear regression up to the threshold of set and an exponential regression thereafter. Permanent set was found to begin at approximately the same initial strain, but the stress level at which set first occurred varied considerably for the various species under investigation.

E. G. Stern, USA

1745. Ivanov, Yu. M., The fundamentals of research on the creep of timbers (in Russian), Investigation of stability, plasticity and creep in building materials, Moscow, 1955, 100–115; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7381.

Expressions are given for determining the flow in elastic hysteresis under constant load:

$$y = y_o + y_n \left[1 - \exp\left(-\frac{t^2}{\tau^2}\right)\right]$$

and the stress relaxation time for a given value of initial deformation:

$$\sigma = \sigma_o - \sigma_n \left[1 - \exp\left(-\frac{t^2}{\tau^2}\right)\right]$$

These formula were given in earlier works by this author.

The deformations were measured by means of portable indicators. Strips with bearing balls were cemented at the ends of the gage length on the edges of the samples, and triangular bearing cups affixed on the bearing ends of the indicator. When measuring deformations with these portable indicators (strain gages), the cups on the gage are in constantly uniform contact with the bearing balls.

The elastic and viscous-elastic hysteresis loops are investigated in relation to the character of the microstructural changes in the wood fibers, and the microstructure of the wood is examined in destruction in the shear zone with compression applied outside this zone.

The residual changes in form of the wood cells are found only in this shear zone; outside the shear zone no change in the shape of the cells was observed.

The deformations and distortions in the cells were investigated microscopically in regard to the difference between spring and late growth in the annual rings, the wood being compressed along and across the grain, as well as obliquely to the annual rings.

It is found that the residual deformations impressed on the wood in the region of plastic flow do not change with heating. When heated in water to +90°, the shear lines in the cell walls remained unchanged, in which regard the author assumes that shear deformation in the cells is the cause of the appearance of residual plastic deformation and creep. F. P. Belyankin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1746. Gerard, G., and Gilbert, A. C., A critical strain approach to creep buckling of plates and shells, *J. Aero/Space Sci.* **25,** 7, 429–434 + 458, July 1958.

The major portion of this paper deals with creep buckling experiments on aluminum cylinders subjected to compression and torsion. These experiments are correlated with the critical strain approach and agreement is obtained in terms of critical strain and critical time. This critical strain approach assumes that the critical strain for short-time buckling is the same as the strain under creep buckling. Examination of the test data on long flat plates under compression shows that the theory proposed may be adequate for plates of small width-thickness ratios. Plates with large width-thickness ratios which buckle under initial application of load require an analysis of the postbuckled state under creep conditions.

J. Marin, USA

1747. Sentis, A., Stationary movement in interphase phenomena (in French), *C. R. Acad. Sci., Paris* **245,** 21, 1776–1778, Nov. 1957.

Through theory using vector potential of displacement, author obtains solution for time-dependence of liquid ascending a vertical plane. Ordinary viscosity and a relaxation time describing elastic effects are included. Comparison with experiment indicates that this concept adequately describes the phenomena of dynamic surface used by other authors. W. C. Griffith, USA

1748. Desov, A., Means for application of the mechanics of elastic-viscous-plastic media for solving the problem of the moulding of ferro-concrete components (in Russian), Investigation of stability, plasticity and creep in building materials, Moscow, 1955, 138–169; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6093.

From the theory of elastic-viscous-plastic media an analysis is made of the most important means for moulding concrete mixes. As basic characteristics of structurally and mechanically suitable cements the following properties are examined: the structural viscosity, the boundary stress due to shear, the momentary modulus of elasticity and the relaxation time. A scheme is proposed by the author for a vibro-viscometer of the ball type, and curves are submitted illustrating the influence of the vibration frequencies, the amplitudes, the water/cement ratio and the plasticizing additives effect on the structural viscosity and other mechanical characteristics of cement mixes. The problems are examined of the vibration punching and rolling of ferro-concrete parts. A dynamic method of determining the momentary modulus of elasticity E_0 is described, as also the time of relaxation T of a medium the equation of whose composition is recorded in the form of $E_0 T\dot{\epsilon} + E\epsilon = T\dot{\sigma} + \sigma$, where E is the prolonged modulus of elasticity, σ the stress, ϵ the deformation. Experimental data are given for the determination of the characteristics E_0 and T. N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1749. Vassiliev, L. P., Butkevich, L. M., and Orekhov, E. I., The influence of speed and degree of plastic extension on the relaxation and subsequent capacity for deformation of metals, Part I (in Russian), *Fiz. Metallov i Metallovedeniye* **2,** 1, 142–145, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7329.

Copper and aluminum wire were stretched at two different rates to five different degrees of deformation in the plastic region, after which stress relaxation was observed.

It is demonstrated that with a high rate and intensity of deformation the relaxation curves extend higher. Samples stretched at a high speed and experiencing relaxation, give, on repeated extension at low speed, a higher stress value than directly deformed samples. These results are explained by the formation of a different system of lattice distortion at high rates of deformation than at a low rate of deformation. M. A. Bol'shanina

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1750. Vassiliev, L. I., and Spevak, L. A., The influence of speed and degree of plastic extension on the relaxation and subsequent capacity for deformation of metals, Part II (in Russian), *Fiz.*

Metallov i Metallovedeniye **2**, 1, 146–148, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7330.

Samples of tin were stretched at two different rates to four different degrees of deformation, after which relaxation took place. It was found that the relaxation curves of the samples which had been stretched at the higher rate continue higher than the curves for the samples deformed at the lower rate, but the difference is considerably less than in the case of copper and aluminum [see preceding review]. The relaxation curves for different rates of deformation converge after 30–40 minutes. The curves for a second extension, at the lower rate, of samples previously deformed at the higher rate, continue somewhat higher than those for samples stretched previously at the lower rate and experiencing relaxation at the same stress value as in the first case.

M. A. Bol'shanina
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plasticity

(See also Revs. 1740, 1747, 1748, 1749, 1750, 1814, 1820, 1849, 1898, 2028)

1751. Prager, W., Shakedown in elastic, plastic media subjected to cycles of load and temperature, Symposium on plasticity in the science of construction, Pap. 14, 6 pp.; Nicola Zanichelli Editore, Bologna, 1957.

In a body subjected to surface tractions, body forces, and temperature changes, shakedown is defined as the process via which plastic flow in the body will eventually stop. A shakedown theorem is given which states; "Shakedown will occur if a state of self-stress can be found such that superposition of this state and the purely elastic response to the given variation of surface traction, body force, and temperature will at no point or instant lead to stresses at or above the yield limit." This theorem is proven using the principle of virtual work, and it is noted that the test state of self-stress need not be the state of residual stress to which the system will shakedown. D. Kececioglu, USA

1752. Finzi, L., Unloading processes in elastic-plastic structures (in English), 9th Congres Intern. Mécan. Appl., Univ. Bruxelles, 1957; **8**, 5–12.

Structures consisting of prismatic elements made of material exhibiting nonlinear stress-strain relation upon loading and linear relation upon unloading are considered. A determinantal equation for finding the loading condition under which unloading process begins is set up. This equation is the same as the one encountered in the solution of elastic trusses for a loading condition causing zero axial force in a member. The presented procedure is illustrated on a truss whose loading is gradually increased. Strengthening of the structure as a consequence of unloading in one of the members is pointed out. Next, the procedure is adapted and illustrated on a statically indeterminate prismatic beam.
E. P. Popov, USA

1753. Rzhanitsyn, A. R., Approximate solutions of problems in the theory of plasticity (in Russian), Issledovaniya po Vopr. Stroit. Mekhan. i Teorii Plastichnosti, Moscow, 1956, 6–65; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5937.

The kinematic method of determining the load limit is developed, because of the circumstances that the possible kinematic field of velocities lends itself to accuracy for some parameters or functions. The latter are determined from the conditions of minimum work. As examples of the application of the theory the following problems are solved: the clean torsion of a plastic rod; the boundary condition of a round rod when subjected to torsion with tension and torsion with bending, and also the problem on the compression of a cylinder in the presence of friction on the faces. For the solution of a number of problems a concept is introduced regarding "concentrated deformations"; that is, fields are examined where the deformation is localized in a thin layer near the surfaces, dividing parts of the bodies remaining stiff. By this means the problem of the shear of a compressed prism and the plane problem of the punch are solved. Some evaluations of the solutions are made. For a single-axis tension of a plate the method of concentrated deformations gives the same value of the limiting load as for continuous flow. The lines of concentrated deformations here show a declination of 35° 17'; this agrees with the experimental data.

The problem is solved of the transverse deflection of a narrow plate in its plane; in so doing the configuration of the lines of concentrated deformations corresponding to the mimum values of external loading is sought. An equation is obtained for the family of extremes of the concentrated deformations, and also a formula for the limit (minimum) of load, corresponding to the concentrated deformations, going by the extremes. With the aid of these formulas the solution of the problem on the boundary equilibrium of the strip, being subjected to the action of a bending moment and a transverse force, is made more precise. In order to find the initial and end points of the extremes, situated on the edges of the plate, a condition is set up for the transversality of the extremes of the concentrated deformations of a thin plate. The utilization of this condition permits the solution of the eccentric compression or tension of a rectangular plate. The theory is also applicable to the calculations for rotating discs. When solving the problems on the deflections of plates Kirkhoff's hypothesis is accepted as correct, while the deformations of the plate are given in the form of the function of deflection $w(x, y)$, satisfying the conditions of fastening. For a plate hinge-supported around the circular outline the result of the solution differs little from the known precise solutions. The limiting loads are indicated for plates of polygonal outline and of hinge-supported curvolinear contour. The method permits taking account of membrane stresses in plates made of plastic materials. The case is examined where the plate has some displaced neutral layer, relative to the mean surface, in which some deformation or other is absent. The basic equation is obtained from the condition of the equality of increase in the full work of the internal and external forces on the infinitely small increase of deformations. The problem of the polygon-shaped hinge-supported plate with large deflections is solved for two cases: (a) when the edges of the plate can travel freely in its plane, (b) when the edges are fastened. This method is also applicable to the problem of the stability of a plate compressed beyond the elasticity limit, taking into consideration the influence of large deflections. The marginal problem is also solved on the boundary equilibrium of a cylindrical shell, loaded evenly with radial forces distributed along the section's contour. The minimum value of the boundary load is given. The bibliography quoted does not reflect the present-day position of the question. M. A. Koltunov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1754. Urbanovsky, V., The elastic-plastic deformation of a thick-walled sphere under the action of an internal pressure (in Russian), *Byul. Polskoy Akad. Nauk Otd.* (4) **4**, 2, 77–83, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7091.

The stress and distortion of a homogeneous, isotropic sphere under uniform internal pressure is examined, the relationship between the stress and deformation intensities being introduced in the form of three sections: elastic, ideally-plastic, and a region of linear strain-hardening. V. A. Lomakin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1755. Schlechtweg, H., Two-dimensional problem of a plastic material obeying Coulomb law of yield (in German), *ZAMM* **38**, 3/4, 139–148, Mar./Apr. 1958.

Plane problems of a general plastic material obeying Coulomb yield condition, i.e. a material whose shear yield stress in slip plane is influenced by mean compressive stress, are discussed. Introducing a new variable, relations among the characteristics of fundamental differential equations of the stress field are derived. Proof is given of the coincidence of the characteristics and slip-lines, and an expression of complete integration of characteristic equations is presented.

Reviewer does not believe the results presented are essentially new, or that the mathematical method employed is the most straightforward. For example, equations (2.5) and (3.7) are equivalent to expressions in Hill's book [AMR **4**, (1951), Rev. 2471, p. 298, equations (30) and (30′); the proof of equivalency may be very easy]. Furthermore, the matters in Sec. 3 of the paper appear to be substantially contained in Hill's book [p. 298, equations (31) and (32)].

Y. Yamada, Japan

1756. Weiss, V., Residual stress in cylinders, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 53–56, 1958.

New equations for the determination of residual stresses in solid and hollow cylinders are given, and it is shown that the new equations are equivalent to the equations first derived by G. Sachs. These new equations offer considerable advantages because they can readily be solved by graphical computation methods. The graphical stress determinations are described.

From author's summary by R. Weck, England

Rods, Beams and Strings

(See Revs. 1733, 1783, 1787, 1885, 1896)

Plates, Shells and Membranes

(See also Revs. 1735, 1754, 1790, 1791, 1806, 1998)

1757. Keller, H. B., and Reiss, E. L., Iterative solutions for the non-linear bending of circular plates, *Comm. Pure Appl. Math.* **11,** 3, 273–292, Aug. 1958.

Paper gives solution to important and extremely difficult problem of the nonlinear deformation of a circular plate under lateral pressure. The iterative procedure used is examined mathematically and by a series of trial numerical solutions. Graphs are given for deflections, slopes, membrane and bending stresses. Work on other similar problems is in hand and reports are promised.

W. S. Hemp, England

1758. Ojalvo, M., and Hull, F. H., Effective width of thin rectangular plates, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM3 (*J. Engng. Mech. Div.*), Pap. 1718, 21 pp., July 1958.

1759. Aare, I. I., The calculation of flexible plates working in shear (in Russian), *Trudi Tallinsk. Politekhn. In-ta* A, no. 65, 61–75, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7029.

The transcritical transformation of rectangular plates under a shear stress uniformly distributed along the edges is examined. It is assumed that the plate is hinge-connected with reinforcing ribs. The solution is presented in three variants: (1) The ribs infinitely rigid in bending, and their rigidity to compression is zero; (2) ribs nonresistant (nonrigid) in bending, and infinitely rigid in compression; (3) ribs infinitely rigid, both in bending and compression.

In the investigation of the first two variants the flexural function is presented in the form:

$$w = \sum_{m=1}^{3} \sum_{n=1}^{3} w_{mn} \sin \frac{mnx}{a} \sin \frac{nny}{b} \qquad [1]$$

where a, b are the sides of the plate, $(m + n)$ is an even number. Eq. [1] contains five variable parameters, w_{11}, w_{33}, w_{13}, w_{31}, W_{33}, while in the previous solutions of Bergmann ["Behaviour of buckled rectangular plates," Stockholm, 1948] only two parameters were considered: w_{11} and w_{33}. Substituting Eq. [1] in one of the Karman equations, author determines the stress function in the median plane. He then applies Bubnov's method ["An evaluation of the work of Prof. S. P. Timoshenko: 'On the stability of elastic systems.'" *Sbornik In-ta inzh. put. soobshch.* no. 13, 1913; Selected Works, Sudpromgiz, 1956, 136–139]. The problem is reduced to the solution of a system of five algebraic equations of the third order, performed for the case of a square plate by the method of successive approximations.

In the third variant, all three displacements of the points u, v and w on the median plane are approximated. The expressions for u and v contain two of the parameters to be varied, that for w the other two. The method of Ritz and Bubnov are next applied. The results are found to be equivalent for the case that in the solution by Bubnov's method the equation of equilibrium is written in the generalized form:

$$D\nabla^2\nabla^2 w - t\left[\sigma_x \frac{\partial^2 w}{\partial x^2} + \sigma_y \frac{\partial^2 w}{\partial y^2} + 2\tau_{xy} \frac{\partial^2 w}{\partial x \partial y} + \left(\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y}\right) \frac{\partial u}{\partial x} + \left(\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{xy}}{\partial x}\right) \frac{\partial w}{\partial y}\right] = 0 \qquad [2]$$

where t = thickness of the plate, σ_x, σ_y, τ_{xy} catenary stresses. The computations were made in this case also for a square plate.

Curves are given, enabling the bending deflections, catenary and bending stresses for a given load to be determined. The form of wave formation in different loading stages is described.

It would be desirable to have this more rigorous solution extended also to the case of cylindrical panels of circular contour.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1760. Kitover, K. A., Calculations for rectangular plates on an elastic foundation (in Russian), *Sb. Tr. Obshchetekhn. Kafedr Leningr. Tekhnol. In-ta Kholodul'n. Prom-sti* **8,** 66–70, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5909.

A calculation is given for the deflection of rectangular plates, resting on an elastic foundation, following the hypothesis of Tsimmerman-Vinkler. The solution for deflection w of the plate is sought in the form

$$w = w_0 + \sum c_j u_j \qquad (j = 1, 2, \ldots)$$

where w_0 is a particular solution satisfying the equation

$$\nabla^2 w + \beta^4 w = \frac{q}{N} \qquad [1]$$

while w_j is the combination of functions, each of which appears as an integral of Eq. [1] and satisfies the boundary conditions on the same edges of the plate as w_0. The system of functions w_j breaks up into a group of symmetrical w_j^+ and obliquely symmetrical functions w_j^-. Correlations are brought in, determining up to a constant common multiple the sought after function w_j for the boundary conditions customarily encountered. A method is described for the determination of the parameter entering into the solution.

A. G. Ishkova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1761. Karrholm, G., Influence functions of elastic plates divided in strips (in English), *Trans. Chalmers Univ. Technol.* no. 201, 18 pp., 1958.

The partial differential equation is solved approximately by dividing the plate in strips and substituting finite differences for

derivatives with respect to one of the variables. Influence functions applicable to various boundary conditions are derived to facilitate the calculations. Their use is demonstrated upon a square plate with three edges simply supported and one edge clamped.

From author's summary by G. Sonntag, Germany

1762. Haythornthwaite, R. M., and Shield, R. T., A note on the deformable region in a rigid-plastic structure, *J. Mech. Phys. Solids* **6,** 2, 127–131, 1958.

Paper contains an interesting extension of the work of Bishop, Green and Hill for a deformable body into a consideration of structures. Authors exemplify the theory with the point loading of a thin plate clamped at its periphery. They show that the deformable region is that contained in the largest circle contained within the plate and centered at the point load.

J. F. W. Bishop, England

1763. Zorski, H., A semi-infinite strip with discontinuous boundary conditions (in English), *Arch. Mech. Stos.* **10,** 3, 371–398, 1958.

The problem of bending of a semi-infinite strip supported on the infinite edges and in a discontinuous manner (sectionally clamped) along the finite edge is solved by the author in two stages. In the first stage, using the solution for a semi-plane obtained by author in a previous paper, author finds Green's function for deflection of a semi-strip clamped along the short edge. The causes of deflection are forced vertical displacements and deflection angles at this edge.

The second stage consists in deriving and solving an integral equation constituting the condition of vanishing of the bending moments on the simply supported segments of the short edge. The kernel of this equation is expressed by means of Green's functions obtained previously in a closed form. Discontinuities and singularities appearing at points of sudden change of support conditions are discussed in detail.

Analogous procedure is adopted in the case of a semi-infinite strip partially simply supported, partially free.

M. Sokolowski, Poland

1764. Brcic, V., Contribution to the solution of plane elasticity problems (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 47–55.

An H-shaped plate is considered subject to a uniform vertical tension across the top and bottom of the vertical "legs." The "bar" part of the plate is a square, the vertical legs are half as wide and twice as long as the bar, and the reentrant corners have fillets. Airy's stress function, satisfying the biharmonic equation, is calculated numerically by relaxation methods. Stresses are also obtained by the photoelastic method. The limiting case of an infinite plate with two infinite notches above and below a horizontal bar is also considered. The stresses are determined by conformal mapping methods. For both the finite and the infinite plate what is of interest is the stress concentration at the reentrant corners. This is found to be the same for the square-shaped bar. Values are also given for various dimension ratios of the bar in the infinite plate and these values may be expected to approximate stress concentration values for a finite plate.

R. A. Clark, USA

1765. Kabulov, V. K., Determination of the basic function in calculations for the components of a plane stressed condition of a plate by use of the variation method (in Russian), *Trudĭ In-ta Sooruzhenii Akad. Nauk.* UzSSR no. 6, 51–67, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5864.

An approximate way is indicated which simplifies the application of the variation method to the problem on the plane stressed condition of a rectangular plate. For the stress functions, successful expressions are proposed for different cases of load distribution along the plate edges, and also when spatial forces are acting. The boundary conditions are satisfied. Some examples are examined.

N. A. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1766. Sokolowski, M., The bending of transversally nonhomogeneous plates of moderate thickness (in English), *Arch. Mech. Stos.* **10,** 3, 315–328, 1958.

The problem under consideration is that of bending of a transversally nonhomogeneous plate of medium thickness. The plate is bounded by the planes $z = \pm h$. It is assumed that $E(2) = E(-2) = \text{const}$. The plate is subjected to a uniformly distributed load normal to the plane $z = -h$ or to bending by forces $f(x, y) = \text{const}$ distributed along the edge of the plate. The boundary conditions for the edge surfaces are satisfied in the integral manner. General equations for displacements and stresses are obtained in both cases.

Z. Mossakowski, Poland

1767. Chien, W.-Z., and Yeh, K.-Y., On the large deflection of rectangular plates (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 403–412.

Author determines deflections and stresses in uniformly loaded, clamped, rectangular plates by expanding load, transverse, and membrane displacements in power series in the center deflection, as done previously [AMR **10** (1957), Rev. 1051] for circular plates. Coefficients in series are obtained by solving appropriate differential equations. Linear term (corresponding to small-deflection theory) and cubic terms suffice for square plates over range of previous theoretical and experimental investigations. Coefficients in series are taken as polynomials in the Cartesian coordinates of the midplane. Reviewer believes that higher degree polynomials might be needed with other boundary conditions.

S. Gratch, USA

1768. Klein, B., A simple method of matric structural analysis: Part III—Analysis of flexible frames and stiffened cylindrical shells, *J. Aero. Sci.* **25,** 6, 385–394, June 1958.

The method of Part II of this paper is extended to cylindrical fuselages under loads and thermal strains. The structure consists essentially of curved panels each of constant radius, tapered longerons and ring elements which may have a varying curvature and cross section. To account for the direct stress-carrying effect of panels the shear flow is expressed in power series of the angle subtending each curved element. Once more, as in the author's previous work, all equilibrium and force-displacement equations for the elements are written down and solved in conjunction with the boundary conditions and inter-element continuity equations for all unknown forces and displacements. The method is illustrated on a uniform single-bay, cantilever cylinder of circular cross section.

J. H. Argyris, England

1769. Salet, G., Regularization of constraints and deformations in a thin cylindrical rotational reinforced shell loaded with a uniform normal pressure (in French), *C. R. Acad. Sci., Paris* **246,** 15, 2218–2219, Apr. 1958.

1770. Matildi, P., Basis for the study of thin shells of arbitrary shape in flexure (in Italian), *G. Genio Civ.* **96,** 2, 116–135, Feb. 1958.

After a brief review of previous work on this topic, the equilibrium equations for the analysis of a thin shell of arbitrary shape are derived with the aid of fundamental expressions of differential geometry. Flexure of the shell is not neglected. It is shown that the general treatment reduces to the known results for plates, for shells of revolution, etc.

B. A. Boley, USA

1771. Hellman, O , Contributions to the general theory of shells with specific regard to the boundary effects and to flat shells (in German), *Ann. Acad. Scient. Fennicae (A) I. Math.-Phys.* no. 213, 71 pp., 1955.

A doctoral dissertation traces first, briefly, the history of the development of the shell theory in tensorial form. After a short section on tensor calculus, that would well serve as a refresher but not as an introduction for the uninitiated, the equilibrium and displacement equations are derived in tensorial notation. Restrictions introduced: (a) the displacements considered are small compared with the shell thickness; (b) normals to the midsurface remain straight and normal to the deformed surface; (c) Hooke's law is valid for the homogeneous material used; (d) normal stresses in the direction of the normal mentioned are zero. Resulting differential equations are simplified by neglecting terms that are small of a higher-order than the dominant terms retained. Special cases investigated: (1) edge effects in shells of rotation with boundary (a) along a meridian circle, (b) in a plane containing the axis of the shell; (2) shallow shells bounded by a plane curve. An iterative experimental solution is proposed for the last case.

Although of research interest, reviewer doubts whether many practising engineers could apply the results in the form presented.

G. Sved, South Australia

1772. Tension in underground pipes (in German), *Bauingenieur* **33**, 2, 67–70, Feb. 1958.

1773. Hicks, R , Theoretical analysis of the stresses induced in a spherical pressure vessel due to the constraining effect of a cylindrical skirt, Instn. Mech. Engrs., Prepr., 14 pp., 1958.

Taking the skirt as being made of two sections having different thicknesses, one section being located inside the vessel and the other directly underneath on the outside of the vessel, expressions are obtained for the bending moments and shear forces induced in the vessel and its skirts when (1) the vessel is stressed by a uniform radial pressure and (2) the skirts are loaded in a axial direction. The general case of an arbitrary load system is also considered and expressions are obtained for the induced moments and shear forces in terms of a set of constants which can be evaluated readily when dealing with any particular problem.

In an appendix the general solution is used to consider briefly the particular cases (a) temperature gradient in the bottom skirt; (b) self weight of the vessel; (c) axial load on the vessel.

From author's summary by S. C. Das, India

1774. Kammerstein, A G., An investigation into the flexibility and strength characteristics of expansion bends with welded, bent and sharply-curved pipe elbows (in Russian), Tr. Vses. n. -i. in-ta po str-vy obyektov neft. i gaz. prom-sti no. 6, 31–46, 1954; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3696.

1775. Arkilic, G. M , Stresses in rotating thin plates with curvilinear boundaries, *J. Franklin Inst.* **266,** 4, 279–292, Oct. 1958.

With the proper choice of potential function the problem of curvilinear plates rotating at a constant speed about an axis in the plane of the plate is solved. The plates considered have at least two axes of symmetry, one of which is assumed to be the axis of rotation.

Calculations are developed for the plates in the forms of two cusped-epicycloid, dumbbell and cog-wheel, presenting the greatest interest.

It is found that stresses at the boundary in the plates rotating about an axis in the plane of the plate have smaller magnitudes than those in curvilinear plates rotating about axes which are perpendicular to the planes of the plates.

M. M. Stanisic, USA

Buckling

1776. Sala, I., On the inelastic buckling of a tapered bar (in German), State Inst. Tech., Finland no. 3, 87 pp., 1951.

Analysis of inelastic buckling is based on reduced modulus of elasticity, previously assumed by Ylinen as $T = E(\sigma_s - \sigma)/(\sigma_s - c\sigma)$, where E = Young's modulus, σ_s yield stress in compression, σ compressive stress, c constant ≤ 1. The corresponding buckling load is determined for three particular types of tapering and cross section (linear in one dimension, rectangular; linear in two dimensions, square; rotational ellipsoid, circular). For a numerical solution the corresponding integral equation is studied.

Buckling experiments with tapered bars of Finnish pine wood confirm these results for a wide range of slenderness ratios and degrees of tapering.

J. Hult, Sweden

1777. Woinowsky-Kreiger, S., Buckling stability of circular plates with circular cylindrical aeolotropy (in German), *Ing-Arch.* **26,** 129–131, Mar. 1958.

Differential equation of buckling of circular plate under radial pressure is transformed to a Bessel equation. Form of solution is taken so as to satisfy boundary conditions of a plate without a hole, with boundary built in or freely supported. Curves of critical pressures are presented with values of ratio of elastic constants of the plate taken for abscissas.

Approximate solution for an isotropic plate stiffened with radial and circumferential ribs consists in rating limits inside which critical pressure is to be expected. Two solutions are suggested as limits, the foregoing solution for circular cylindrical aeolotropy case and the solution of plate which is to be taken isotropic for loads laying in its middle plane. For this last case, again using Bessel's function, values of critical pressures are calculated and presented by curves which correspond to the case of built-in and of freely supported boundary.

Mrs. N. Naerlovic, Yugoslavia

1778. Yusuff, S., Buckling phenomena of stiffened panels, *J. Aero/Space Sci.* **25,** 8, 507–514, Aug. 1958.

Various authors have studied the instability of stiffened panels under uniform compressive stresses with either extension or adaption of torsion-bending theory. Levy and Kroll, however, found that the theory and experimental results do not agree for stiffeners having thickness equal to or less than the sheet thickness. Hence the present paper was written to study this problem. The integral construction with unflanged stiffeners was first used to investigate the buckling phenomena.

A biharmonic differential equation for deflection of the surface was written first in the analysis. A solution was proposed. The first set of boundary conditions was obtained through the twisting of the stiffener, while in the second set of boundary conditions the bending of the stiffener was considered.

In the investigation three cases of long wave, short wave, and mixed instability buckling were considered. In the analysis for computing the effective moment of inertia an element of the panel consisting of a stiffener at the center of the skin corresponding to the stiffener spacing was considered. The theoretical analysis presented in the paper and the experimental results done by NACA show good agreement.

Reviewer feels that the analysis is very clear and legitimate, assumptions reasonable, and results good. The paper ought to be a valuable contribution to the design of the compression stiffened panels in the aircraft industry.

C. T. Yang, USA

1779. Seldenrath, T., and Wright, A. W., Notes on buckling of tubing in pumping wells, *J. Petr. Technol.* **10,** 8, 49–51, Aug. 1958.

1780. Harris, L. A., Suer, H. S., and Skene, W. T., The effect of internal pressure on the buckling stress of thin-walled circular cylinders under combined axial compression and torsion, *J. Aero. Sci.* **25,** 2, 142–143 (Readers' Forum), Feb. 1958.

1781. Alumyae, N. A., Determination of the critical load enclosed in the apex of a conical envelope of rotation subjected to external pressure (in Russian), *Trudi Tallinsk. politekhn. in-ta (A)*, no. 65, 5–13, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4619.

Principles are given of a simplification of equations of local stability suggested by K. G. M. Mushtar [*Prikl. Mat. Mekh.* **2,** no. 4, 1939] for the case of a conical envelope closed at the top under the action of external pressure. It is shown that the critical load of an envelope, the length of whose generatrix coincides with the non-zero radius of curvature at the base, can be determined with asymptotic error

$$\sqrt{t/s_0 \cot \beta}$$

(where t is the thickness, s_0 the length of the generatrix, and β the cone angle) from the equation of the fourth power.

The method of simplifying the differential equations has been explained previously by the author.

A. V. Sachenkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1782. Volvich, S. I., A solution of the stability problem in the theory of elasticity (in Russian), *Trudi Saratovsk. Avtomob.-dor. In-ta* **13,** 3–15, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6994.

An energy criterion is developed for the stability of equilibrium of an elastic body, based on the general nonlinear theory of elasticity. It is demonstrated that the criterion of the critical state of equilibrium of an elastic body is represented by the condition of equality to zero of the second variant of the potential energy of deformation accumulated by the body in the equilibrium condition investigated. In the case of a thin rectangular plate uniformly compressed in a single direction, the suggested variational equation leads to a generally known solution for the critical load. The results obtained by this author are not new. A general energy criterion of the stability of a three-dimensional elastic body based on a nonlinear theory was suggested by Trefftz [Int. Kongress f. technische Mechanik, 1930, Pt. II], and further developed by Kreutzer [*ZAMM* **12,** no. 6, 1932]. In this, a value for the critical loading of a compressed bar is obtained which differs from Euler's well-known formula by only 0.1—0.2%.

The present abstractor has demonstrated the derivation of the variational equation and its considerable simplification in application to the theory of elastic plates and shells [*Izv. fiz.-matem. o-va, Kazan* (3), 11, 1938]. A generalization of the theory for the case when the external forces change with deformation is given in the book by V. V. Novozhilov ["Fundamentals of the nonlinear theory of elasticity," Moscow, Gostekhizdat, 1948].

Kh. M. Mushtari

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1783. Volvich, S. I., Approximate method for calculations of the stability of some elastic systems (in Russian), *Sb. Nauch. Soobshch. Saratovsk. Avtomob.-dor. In-ta* no. 3, 8–12, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6049.

The problem is scrutinized regarding the evaluation of the critical condition of a straight rod of constant section when subjected to the action of several longitudinal forces. An approximate formula is advanced, without full justification, for the critical parameter $P = \dfrac{EI}{l^2 \Sigma k_\xi m_\xi}$ in which coefficient $k_\xi = P_\xi / P$ takes into account the influence of forces P_ξ, applied to the separate points on the axis, while $\pi \sqrt{m_\xi}$ is the coefficient of length for a singly acting force P_ξ. The inaccuracy of the values may reach 10%. A similar formula is advanced by A. P. Korobov ["Approximate method for calculations of braces," Rostov, 1936]. A. N. Dinnik also used this formula ["Longitudinal bending," Moscow-Leningrad, 1939, p. 106, formula 142].

I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1784. Chelomei, V. N., On the possibility of increasing the stability of elastic systems by means of vibration (in Russian), *Doklady Akad. Nauk SSSR* (N. S.) **110,** 3, 345–347, Sept. 1956.

Vibrations of Solids

(See also Revs. 1670, 1692, 1695, 1696, 1697, 1698, 1784, 1939, 2176)

1785. Handelman, G., Boyce, W., and Cohen, H., Vibrations of a uniform rotating beam with tip mass, Rensselaer Polytechnic Institute Math Rep. 13 (ASTIA AD 152 204), 14 pp., Mar. 1958.

Report discusses the effect of an added mass located at the moving tip upon the transverse vibrations of a uniform cantilever beam rotating with uniform velocity about an axis through a clamped end. It is shown that both numerator and denominator of the quotient derived from Rayleigh's principle are increased by terms containing the extra mass but that the fundamental frequency of vibration is always reduced. To a first approximation the frequencies of very high modes are unaffected by the rotatory motion.

Reviewer thinks use of λ, for angular frequency, gives rise to unnecessary possibility of misleading reader.

M. J. P. Musgrave, England

1786. Messkhi, A. M., The bending vibrations of twisted rods constrained at one end and hinge-jointed at the other (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk Georgian Polytechnic Institute, Tbilisi, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7087.

1787. Mathews, P. M., Vibrations of a beam on elastic foundation (in English), *ZAMM* **38,** 3/4, 105–115, Mar./Apr. 1958.

Author conducted research on a homogeneous beam of infinite length having a uniform cross section, on elastic foundation with a constant coefficient of elasticity k. Vibration creates a force concentrated in a point moving with a constant velocity v and varying in a sinusoidal form with respect to time. The corresponding equation with damping which is proportional to velocity is $EI\partial^4 y/\partial x^4 + \rho\, \partial^2 y/\partial t^2 + \nu\, \partial y/\partial t + ky = F_0 \cos \omega t \cdot \delta(x - vt)$ where δ denotes the Dirac delta function. The solution of the above equation in the form $y(\tau,t) = y_1(\tau) \cos \omega t + y_2(\tau) \sin \omega t$ where $\tau = x - vt$ results in two simultaneous equations. Then assuming the absence of damping, using Fourier's transformation, we get the exact solution. The following cases are examined: (1) A beam under the action of a constant force acting in a constant point; (2) vibration of beam under the action of a stationary force varying with the time, and in this case resonance may occur, when $\omega^2 = k/\rho$; (3) vibration of a beam under a constant moving force, and in this case, loss of stability may occur, when $v = (4EIk/\rho^2)$; (4) vibration of a beam in general case, where also loss of stability may occur if v and ω and the rest of the parameters of the system follow a specified equation.

This theory may be applied e.g. in the case of moving railway tracks.

Paper is very interesting and the solution with the application of damping will make possible a careful discussion of this question.

K. Piszczek, Poland

1788. Tosatto, G., Torsional vibrations of crankshafts and their amplitude. I, Torsional oscillation of crankshaft (in Italian), *Ingegnere* **31**, 11, 987–995, Oct. 1957.

"Impedance" method, as proposed by P. F. Chenea [*J. Appl. Mech.* June 1953; AMR **6** (1953), Rev. 2157] is used for solving problem of torsional vibrations of crankshafts. Linear elastic behavior and linear viscous damping are assumed. An equivalent straight shaft is substituted for the real shaft and rules are given for this substitution. Computation of natural frequencies and amplitudes of vibrations and of relative rotations of sections in crankshafts is performed by means of dynamically equivalent straight shaft. Numerical example is given for a four-cylinder engine crankshaft. H. Fernandez Long, Argentina

1789. Apfelbeck, A., Mathematical theory of torsional and bending vibration of anisotropic bars (in German), *Czechoslovak Math. J.* **7** (82), 3, 374–411, July 1957.

Paper is based on usual technical equations; title seems to refer to treatment of problem. Using conventional techniques (positive definiteness of quadratic form, Green's function, etc.) author proves uniqueness of solution of initial-value problem and various theorems relating to associated eigenvalue problem: reality and non-negativeness of eigenvalues, orthogonality and completeness of eigenfunctions, etc. Existence of solution is postulated.

Inequalities (1,4) are mutually exclusive; the second is apparently in error. E. F. Masur, USA

1790. Thomas, D. A., Characteristic impedances for flexure waves in thin plates, *J. Acoust. Soc. Amer.* **30**, 3, 220–221, Mar. 1958.

Solution is obtained for sinusoidal outgoing radial waves in infinite circular plate, ignoring shear deformation and rotary inertia. From solution, expressions for characteristic impedances for bending moments and shear forces per unit circumference are obtained. Particular notice is taken of driving point impendance for shear-type disturbances, and comparisons are made with results of other authors. H. J. Plass, USA

1791. Onoe, M., Gravest contour vibration of thin anisotropic circular plates, *J. Acoust. Soc. Amer.* **30**, 7, 634–638, July 1958.

Rayleigh's principle is used to determine the lowest frequency and mode shape of a thin anisotropic circular plate vibrating in its own plane. The results are compared with experiments on *X*-cut and *Y*-cut quartz crystals as well as with theoretical results for isotropic plates. D. Young, USA

1792. Hoppmann, W. H., II., Some characteristics of the flexural vibrations of orthogonally stiffened cylindrical shells, *J. Acoust. Soc. Amer.* **30**, 1, 77–82, Jan. 1958.

Author describes briefly the derivation of strain energy expression for orthogonally stiffened cylindrical shells. Equation is obtained for longitudinal, shear, and flexural vibration frequencies of stiffened cylinders with simply supported ends. Experimental flexural vibration frequencies were obtained for unstiffened cylinders and for cylinders with longitudinal stiffeners or circumferential rings.

Comparison of theory (based on equivalent stiffnesses obtained experimentally by the author) and experiment indicates good agreement—the maximum flexural vibration frequency discrepancies being about 20%, but most of the discrepancies being generally less than 5%. Both theory and experiment confirm an effect noted by Arnold and Warburton [*Proc. Roy. Soc. London* (*A*) **197**, p. 238, 1949], that in a certain range lower vibration frequencies are associated with more complex modes. Another phenomenon noted was the incapability of exciting vibration frequencies for increasing circumferential waves with circumferential rings and for increasing longitudinal waves with longitudinal stiffeners with the given driving mechanism. P. Seide, USA

1793. Mludek, H., Computation of the influence of the centrifugal force on the bending vibration of N-stage buckets of condensation steam turbines by the use of automatic computers (in German), *Maschinenbau-Technik* **7**, 4, 208–213, Apr. 1958.

Author derives set of difference equations for calculating the effects of the centrifugal force on the bending frequencies of long tapered steam or gas turbine buckets. He derives four equations which give the shear force, bending moments, slope, and deflections for any point of the bucket. It is demonstrated that the finite difference equations can be made to approximate as accurately as desired the exact solution, by letting the increment of bucket length approach zero. As the increment of bucket length approaches zero, the classical fourth-order partial differential equation of the bending beam is obtained.

Numerical examples are given and compared with the results obtained by methods which use an over-all correction factor to correct for the influence of centrifugal force; author outlines the method of programming the solution of his problem for modern electronic digital computers. He concludes that the effect of centrifugal forces should be calculated from the dynamics equations and not by some empirical formula. Reviewer believes this paper should be of definite interest to engineers interested in the design of steam and gas turbine buckets. W. H. Sellers, USA

1794. Hahn, R. S., Vibrations of flexible precision grinding spindles, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-97, 5 pp.

The effects of pulsating forces between grinding wheel and workpiece are discussed in connection with inhomogeneous wheel wear and loading. By analysis it is shown that pulsating normal forces may be caused by rotary damping and gyroscopic effects. The influence of skew-symmetric rigidity in the spindle is also discussed and the occurrence of subharmonic resonances is pointed out. From author's summary

1795. Yegupov, V. K., The oscillations of roof structures under concentrated loads when supported by frame girders (in Russian), *Trudi Vladivostoksk. Vyssh. Morekhod. Ucb-shche* no. 1, 92–127, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7078.

Author investigates the natural and constrained vibrations under concentrated loading of roof structures supported by elastic frameworks or girders forming the transverse bracings of the framework.

The bar structure is assumed to be replaceable by a continuous elastic surface which reduces the problem of the oscillations of the roof structure to the problem of the oscillation of any equivalent beam on an elastic foundation.

A number of numerical examples are given which illustrate the application of the theory. A. B. Morgaevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1796. Schwarzl, F., Forced bending and extensional vibrations of a two-layer compound linear viscoelastic beam (in English), *Acustica* **8**, 3, 164–172, 1958.

In the forced vibrations of a two-layer viscoelastic beam, four basic cases are to be distinguished: (1) A pure tensile vibration excited by a tensile force and a bending moment; (2) a pure bending vibration excited by a bending moment and a tensile force; (3) a superposition of a bending vibration and a longitudinal vibration under a pure bending moment; (4) a superposition of a longitudinal vibration and a bending vibration under a pure tensile force.

The apparent stiffness against bending or tension, the damping and the energy dissipation in these four cases are discussed as functions of the elastic constants and the ratio of the layers.

From author's summary by R. M. Gray, USA

1797. Strekis, A. M., Forced vibrations of a system with one degree of freedom in the presence of dry friction and with an opera-

ting arbitrary exciting force (in Russian), Vopr. Dinamiki i Dinam. Prochnosti; Riga, Akad. Nauk LatvSSR no. 4, 95–121, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7529.

The equation $\ddot{y} + k^2 y = F(t) \pm R_0$ is examined, where $F(t)$ is the introduced theoretical exciting force, R_0 is obtained from the amplitude of the force of dry friction introduced. For the stationary process, by means of the method of the conservation of initial state, a system of equations was obtained, for the general case, for the determination of the time moments at which the velocity is changed to zero and the friction force changes sign. Examples are examined where the exciting force changes by 90 deg, without change and with change of sign, and for the case of instantaneous impulses. E. N. Miroslavlev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1798. Galaka, P. I., Experimental investigation of an impulse vibration damper when free vibrations are operating (in Russian), *Dopovidi Akad. Nauk URSR* no. 3, 238–240, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7545.

Some results are given of the experimental investigation of vibration extinguisher when free vibrations are acting. It was shown that the action of the vibration extinguisher emerges as a clearcut damping of vibration, during which this damping increases with the increase in the relation of the intercolliding masses and the clearance between them. The logarithmic decrement of the system with a vibration extinguisher is greater than in a system without a vibration extinguisher; at one and the same correlation of the masses it increases with increase of clearance and with diminution of vibration amplitude. An insignificant reduction was also disclosed in the frequency of free vibrations, which depended on the parameters of the vibration extinguisher. The experimental results were found to be in agreement with the theoretical functions.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1799. Pisarenko, G. S., and Khilichevskii, V. V., Geometrical parameters of a hysteresis loop as characteristics of the damping properties of a material (in Russian), Vopr. poroshkovoi metallurgii i prochnosti materialov, Kiev, Akad. Nauk USSR, no. 3, 1956, 108–116; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4668.

For describing the energy dispersion in a material during oscillation use is made of N. N. Davidenkov's relationship [*Zh. tekh. Fiz.* **8**, 6, p. 483, 1938] between the stress σ in the case of a symmetrical cycle and the extension ϵ

$$\sigma = E\left\{\epsilon \mp \frac{\eta}{n}\left[(\epsilon_0 \pm \epsilon)^n - 2^{n-1}\epsilon_0^n\right]\right\}$$

where η and n are the parameters of the hysteresis loop obtained from damping tests on a rod of rectangular section oscillating in pure bending conditions.

Formulas were obtained for determining the mean damping decrement in specimens of rectangular section with a section in the form of a segment and with a section formed by the uses of two radii. The experimental data in no case differ from the calculated ones by more than 5%. Formulas and graphs are given of the relationship of the mean damping decrement to the stress for turbine blades of constant and variable section; difficulties were encountered in obtaining the experimental data. D. M. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1800. Ziemba, S., Free vibration with damping of marked nonlinear character (in English), *Arch. Mech. Stos.* **9**, 5, 525–548, 1957.

Author discusses the differential equation of vibrating motion of a material point with one degree of freedom, with linear elastic and nonlinear "positive" damping properties depending on velocity only.

The damping is classified into "hard" and "soft" damping. Both cases are treated in detail. Analytic considerations are illustrated by numerous diagrams. For "hard" damping the conclusions from Sansone's theorem are interpreted.

It is also found that with suitable damping characteristics the vibrating motion tends asymptotically, after a finite number of oscillations, to the equilibrium position if the time increases indefinitely. K. Piszczek, Poland

1801. Ando, N., Fundamental studies on non-linear vibrations of building structures in plastic range, *Bull. Fac. Engng., Yokohama Nat. Univ.* **7**, 1–14, Mar. 1958.

Analysis is made of the vibration of a system with a single degree of freedom having a nonlinear restoring force which exhibits hysteresis. Differential and integral equations are obtained and applied to establish the condition of stationary response to sinusoidal forces. The stability of these motions is examined using a method of perturbation. The special case where the restoring force is quadratic is examined in some detail, under a restriction of size of amplitude, while numerical solutions for larger amplitudes are also given. These last show that the more approximate solution has a range of validity important for practice.

Paper is written in connection with studies of building response to earthquakes, but has wide application. Its important contribution is somewhat marred by printing errors.

W. S. Hemp, England

1802. Powell, A., On the measurement of pressure correlations for random vibration studies, *J. Acoust. Soc. Amer.* **30**, 9, p. 878 (Letters to the Editor), Sept. 1958.

Note briefly discusses some desirable qualities of pressure correlation measurements from the point of view of applications to random vibration analysis. It appears that an analog method has considerable merit; that is, a suitable electrical filter may be used to provide an electrical analog of the mechanical motion of each normal mode of a structure subjected to a random pressure field.

From author's summary

1803. Basel, C. V., New possibilities in the design of instruments for vibration measurements (in German), *Arch. Tech. Messen u. Indust. Messtech.* no. 273, 201–204, Oct. 1958.

1804. Smith, E. R., Edelman, S., Jones, E., and Schmidt, V. A., Stroboscopic interferometer for vibration measurement, *J. Acoust. Soc. Amer.* **30**, 9, 867–870, Sept. 1958.

Paper describes measurement of vibration amplitude with a Fizeau-type interferometer using pulses of monochromatic light of adjustable phase. The interferometer is used to calibrate vibration pickups over the frequency range from 100 to 20,000 cps.

From authors' summary

1805. Amiantov, I. N., and Tikhonov, V. I., Effect of normal fluctuations on standard nonlinear members (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk.* no. 4, 33–41, Apr. 1956.

Wave Motion and Impact in Solids

1806. Kaliski, S., Dynamic problem of the rectangular parallelepiped (in English), *Arch. Mech. Stos.* **10**, 3, 329–370, 1958.

The problem under consideration is that of a homogeneous elastic rectangular parallelepiped loaded by a sinusoidally variable field of volume forces with boundary conditions concerning the way of fixing the walls. It is assumed that the frequency of the vibration forcing field is contained within certain bounded intervals.

For the basic system assumed, the Green tensor is used to write a system of six integral equations constituting the conditions of

1788. Tosatto, G., Torsional vibrations of crankshafts and their amplitude. I, Torsional oscillation of crankshaft (in Italian), *Ingegnere* **31**, 11, 987–995, Oct. 1957.

"Impedance" method, as proposed by P. F. Chenea [*J. Appl. Mech.* June 1953; AMR **6** (1953), Rev. 2157] is used for solving problem of torsional vibrations of crankshafts. Linear elastic behavior and linear viscous damping are assumed. An equivalent straight shaft is substituted for the real shaft and rules are given for this substitution. Computation of natural frequencies and amplitudes of vibrations and of relative rotations of sections in crankshafts is performed by means of dynamically equivalent straight shaft. Numerical example is given for a four-cylinder engine crankshaft. H. Fernandez Long, Argentina

1789. Apfelbeck, A., Mathematical theory of torsional and bending vibration of anisotropic bars (in German), *Czechoslovak Math. J.* **7** (82), 3, 374–411, July 1957.

Paper is based on usual technical equations; title seems to refer to treatment of problem. Using conventional techniques (positive definiteness of quadratic form, Green's function, etc.) author proves uniqueness of solution of initial-value problem and various theorems relating to associated eigenvalue problem: reality and non-negativeness of eigenvalues, orthogonality and completeness of eigenfunctions, etc. Existence of solution is postulated.

Inequalities (1,4) are mutually exclusive; the second is apparently in error. E. F. Masur, USA

1790. Thomas, D. A., Characteristic impedances for flexure waves in thin plates, *J. Acoust. Soc. Amer.* **30**, 3, 220–221, Mar. 1958.

Solution is obtained for sinusoidal outgoing radial waves in infinite circular plate, ignoring shear deformation and rotary inertia. From solution, expressions for characteristic impedances for bending moments and shear forces per unit circumference are obtained. Particular notice is taken of driving point impendance for shear-type disturbances, and comparisons are made with results of other authors. H. J. Plass, USA

1791. Onoe, M., Gravest contour vibration of thin anisotropic circular plates, *J. Acoust. Soc. Amer.* **30**, 7, 634–638, July 1958.

Rayleigh's principle is used to determine the lowest frequency and mode shape of a thin anisotropic circular plate vibrating in its own plane. The results are compared with experiments on *X*-cut and *Y*-cut quartz crystals as well as with theoretical results for isotropic plates. D. Young, USA

1792. Hoppmann, W. H., II., Some characteristics of the flexural vibrations of orthogonally stiffened cylindrical shells, *J. Acoust. Soc. Amer.* **30**, 1, 77–82, Jan. 1958.

Author describes briefly the derivation of strain energy expression for orthogonally stiffened cylindrical shells. Equation is obtained for longitudinal, shear, and flexural vibration frequencies of stiffened cylinders with simply supported ends. Experimental flexural vibration frequencies were obtained for unstiffened cylinders and for cylinders with longitudinal stiffeners or circumferential rings.

Comparison of theory (based on equivalent stiffnesses obtained experimentally by the author) and experiment indicates good agreement—the maximum flexural vibration frequency discrepancies being about 20%, but most of the discrepancies being generally less than 5%. Both theory and experiment confirm an effect noted by Arnold and Warburton [*Proc. Roy. Soc. London* (*A*) **197**, p. 238, 1949], that in a certain range lower vibration frequencies are associated with more complex modes. Another phenomenon noted was the incapability of exciting vibration frequencies for increasing circumferential waves with circumferential rings and for increasing longitudinal waves with longitudinal stiffeners with the given driving mechanism. P. Seide, USA

1793. Mludek, H., Computation of the influence of the centrifugal force on the bending vibration of N-stage buckets of condensation steam turbines by the use of automatic computers (in German), *Maschinenbau-Tecbnik* **7**, 4, 208–213, Apr. 1958.

Author derives set of difference equations for calculating the effects of the centrifugal force on the bending frequencies of long tapered steam or gas turbine buckets. He derives four equations which give the shear force, bending moments, slope, and deflections for any point of the bucket. It is demonstrated that the finite difference equations can be made to approximate as accurately as desired the exact solution, by letting the increment of bucket length approach zero. As the increment of bucket length approaches zero, the classical fourth-order partial differential equation of the bending beam is obtained.

Numerical examples are given and compared with the results obtained by methods which use an over-all correction factor to correct for the influence of centrifugal force; author outlines the method of programming the solution of his problem for modern electronic digital computers. He concludes that the effect of centrifugal forces should be calculated from the dynamics equations and not by some empirical formula. Reviewer believes this paper should be of definite interest to engineers interested in the design of steam and gas turbine buckets. W. H. Sellers, USA

1794. Hahn, R. S., Vibrations of flexible precision grinding spindles, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-97, 5 pp.

The effects of pulsating forces between grinding wheel and workpiece are discussed in connection with inhomogeneous wheel wear and loading. By analysis it is shown that pulsating normal forces may be caused by rotary damping and gyroscopic effects. The influence of skew-symmetric rigidity in the spindle is also discussed and the occurrence of subharmonic resonances is pointed out. From author's summary

1795. Yegupov, V. K., The oscillations of roof structures under concentrated loads when supported by frame girders (in Russian), *Trudl Vladivostoksk. Vyssh. Morekbod. Uch-shche* no. 1, 92–127, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7078.

Author investigates the natural and constrained vibrations under concentrated loading of roof structures supported by elastic frameworks or girders forming the transverse bracings of the framework.

The bar structure is assumed to be replaceable by a continuous elastic surface which reduces the problem of the oscillations of the roof structure to the problem of the oscillation of any equivalent beam on an elastic foundation.

A number of numerical examples are given which illustrate the application of the theory. A. B. Morgaevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1796. Schwarzl, F., Forced bending and extensional vibrations of a two-layer compound linear viscoelastic beam (in English), *Acustica* **8**, 3, 164–172, 1958.

In the forced vibrations of a two-layer viscoelastic beam, four basic cases are to be distinguished: (1) A pure tensile vibration excited by a tensile force and a bending moment; (2) a pure bending vibration excited by a bending moment and a tensile force; (3) a superposition of a bending vibration and a longitudinal vibration under a pure bending moment; (4) a superposition of a longitudinal vibration and a bending vibration under a pure tensile force.

The apparent stiffness against bending or tension, the damping and the energy dissipation in these four cases are discussed as functions of the elastic constants and the ratio of the layers.

From author's summary by R. M. Gray, USA

1797. Strekis, A. M., Forced vibrations of a system with one degree of freedom in the presence of dry friction and with an opera-

ting arbitrary exciting force (in Russian), Vopr. Dinamiki i Dinam. Prochnosti; Riga, Akad. Nauk LatvSSR no. 4, 95–121, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7529.

The equation $\ddot{y} + k^2 y = F(t) \pm R_0$ is examined, where $F(t)$ is the introduced theoretical exciting force, R_0 is obtained from the amplitude of the force of dry friction introduced. For the stationary process, by means of the method of the conservation of initial state, a system of equations was obtained, for the general case, for the determination of the time moments at which the velocity is changed to zero and the friction force changes sign. Examples are examined where the exciting force changes by 90 deg, without change and with change of sign, and for the case of instantaneous impulses.

E. N. Miroslavlev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1798. Galaka, P. I., Experimental investigation of an impulse vibration damper when free vibrations are operating (in Russian), *Dopovidi Akad. Nauk URSR* no. 3, 238–240, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7545.

Some results are given of the experimental investigation of vibration extinguisher when free vibrations are acting. It was shown that the action of the vibration extinguisher emerges as a clearcut damping of vibration, during which this damping increases with the increase in the relation of the intercolliding masses and the clearance between them. The logarithmic decrement of the system with a vibration extinguisher is greater than in a system without a vibration extinguisher; at one and the same correlation of the masses it increases with increase of clearance and with diminution of vibration amplitude. An insignificant reduction was also disclosed in the frequency of free vibrations, which depended on the parameters of the vibration extinguisher. The experimental results were found to be in agreement with the theoretical functions.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1799. Pisarenko, G. S., and Khilichevskii, V. V., Geometrical parameters of a hysteresis loop as characteristics of the damping properties of a material (in Russian), Vopr. poroshkovoi metallurgii i prochnosti materialov, Kiev, Akad. Nauk USSR, no. 3, 1956, 108–116; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4668.

For describing the energy dispersion in a material during oscillation use is made of N. N. Davidenkov's relationship [*Zh. tekh. Fiz.* **8**, 6, p. 483, 1938] between the stress σ in the case of a symmetrical cycle and the extension ϵ

$$\sigma = E\left\{\epsilon \mp \frac{\eta}{n}\left[(\epsilon_0 \pm \epsilon)^n - 2^{n-1}\epsilon_0^n\right]\right\}$$

where η and n are the parameters of the hysteresis loop obtained from damping tests on a rod of rectangular section oscillating in pure bending conditions.

Formulas were obtained for determining the mean damping decrement in specimens of rectangular section with a section in the form of a segment and with a section formed by the uses of two radii. The experimental data in no case differ from the calculated ones by more than 5%. Formulas and graphs are given of the relationship of the mean damping decrement to the stress for turbine blades of constant and variable section; difficulties were encountered in obtaining the experimental data.

D. M. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1800. Ziemba, S., Free vibration with damping of marked nonlinear character (in English), *Arch. Mech. Stos.* **9**, 5, 525–548, 1957.

Author discusses the differential equation of vibrating motion of a material point with one degree of freedom, with linear elastic and nonlinear "positive" damping properties depending on velocity only.

The damping is classified into "hard" and "soft" damping. Both cases are treated in detail. Analytic considerations are illustrated by numerous diagrams. For "hard" damping the conclusions from Sansone's theorem are interpreted.

It is also found that with suitable damping characteristics the vibrating motion tends asymptotically, after a finite number of oscillations, to the equilibrium position if the time increases indefinitely.

K. Piszczek, Poland

1801. Ando, N., Fundamental studies on non-linear vibrations of building structures in plastic range, *Bull. Fac. Engng., Yokohama Nat. Univ.* **7**, 1–14, Mar. 1958.

Analysis is made of the vibration of a system with a single degree of freedom having a nonlinear restoring force which exhibits hysteresis. Differential and integral equations are obtained and applied to establish the condition of stationary response to sinusoidal forces. The stability of these motions is examined using a method of perturbation. The special case where the restoring force is quadratic is examined in some detail, under a restriction of size of amplitude, while numerical solutions for larger amplitudes are also given. These last show that the more approximate solution has a range of validity important for practice.

Paper is written in connection with studies of building response to earthquakes, but has wide application. Its important contribution is somewhat marred by printing errors.

W. S. Hemp, England

1802. Powell, A., On the measurement of pressure correlations for random vibration studies, *J. Acoust. Soc. Amer.* **30**, 9, p. 878 (Letters to the Editor), Sept. 1958.

Note briefly discusses some desirable qualities of pressure correlation measurements from the point of view of applications to random vibration analysis. It appears that an analog method has considerable merit; that is, a suitable electrical filter may be used to provide an electrical analog of the mechanical motion of each normal mode of a structure subjected to a random pressure field.

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1805. Amiantov, I. N., and Tikhonov, V. I., Effect of normal fluctuations on standard nonlinear members (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk.* no. 4, 33–41, Apr. 1956.

Wave Motion and Impact in Solids

1806. Kaliski, S., Dynamic problem of the rectangular parallelepiped (in English), *Arch. Mech. Stos.* **10**, 3, 329–370, 1958.

The problem under consideration is that of a homogeneous elastic rectangular parallelepiped loaded by a sinusoidally variable field of volume forces with boundary conditions concerning the way of fixing the walls. It is assumed that the frequency of the vibration forcing field is contained within certain bounded intervals.

For the basic system assumed, the Green tensor is used to write a system of six integral equations constituting the conditions of

vanishing of the displacements in the direction normal to each wall of the parallelepiped. The unknown functions are the reactions normal to the walls of the parallelepiped. The above system is replaced by eight systems of integral equations with three unknowns each. This operation is done by expressing the given mass force field in the form of a sum of eight symmetric or antisymmetric component fields. One of these systems is treated in detail. The unknown reactions are expressed in the form of double trigonometric series with unknown coefficients, for which an infinite system of algebraic equations is obtained. Using the Banach-Schauder theorem, full regularity of the above system is shown, which enables the use of the iteration method. Another solution method—that of perturbation—is given for the above system.

The above method may also be used in the case of free walls. It is indicated that this method may be generalized to orthotropic bodies or to problems concerning bodies composed of several parallelepipeds.

The paper is of purely theoretical character. No example is given. K. Piszczek, Poland

1807. Petrashen', G. I., and Uspenskii, I. N., The propagation of waves in layered isotropic elastic media (in Russian), *Ucb. Zap. LGU* no. 208, 58–141, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5913.

An investigation is carried out of wave fields in layered isotropic elastic media, formed by different concentrated originating centers. First, solutions of the problems are built up for moments of time when the straight waves have not yet reached the boundary nearest the originating source. This is the problem of the unbounded medium or semispace (if the source is on its boundary). Points examined were: the normal, and also the force parallel to the boundaries and the center of rotation, disposed on the free surface and inside one of the layers; the concentrated action of the type of a radially directed field of tangential forces on the free surface; the pressure center within one of the layers. Further, the arrangement is discussed of the basic problems concerned in the propagation of the waves. It is noted that the general solution of the problem in regard to its investigation proved to be unwieldy. The greatest practical value, in fact, is attached to wave-field investigations restricted to a definite interval of time, from the moment of inclusion of the reaction. Consequently, it appears to be worth while to build up solutions taking into account the successive reverberations and break up of the spreading waves on the boundaries of the system. For such a project, use should be made of the solutions of two auxiliary problems: (1) the problem of the rebound and break up of the waves on the boundary separating two semispaces, in a state of rigid contact, and (2) the problem on the rebound of waves from the free boundary of the semispace. Then solutions of the auxiliary problems mentioned are given, covering the cases of axially symmetrical, tangential and rotational forces, and the determination of formulas for displacements due to the spread of the waves in two-, three- and four-layer systems. A method is put forward for the construction of a formula for a wave passing along any route into an n-layered medium, and all the essential auxiliary expressions for such a construction are brought in. A brief exposition is given of the application of the method of stationary phases for the evaluation of the principal parts of the displacement field of rebounding and leading waves in the neighborhood of their fronts, and formulas are obtained corresponding to the evaluations mentioned. The question is raised regarding the recording of these waves by means of an apparatus equipped for wide band and frequency recording. K. I. Ogurtsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1808. Petrashenу, G. I., A rational method of solving problems of dynamic elasticity for laminarly isotropic regions with plane-parallel dividing boundaries (in Russian), *Ucb. Zap. LGU* no. 208, 5–57, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3433.

The fundamentals of the method of contour integrals are expounded. In the introduction a comparison is made between this method and the functionally invariant method of V. I. Smirnov and S. I. Sobolev [*Tr. Seismol. in-ta*, 1932, no. 18; no. 20; 1933, no. 29]. It is maintained that the method of contour integrals is more effective and simpler than the method of complex solutions.

A formal solution is presented for the two-dimensional dynamic problem in the case of a semispace, successively in Cartesian and cylindrical coordinates. In the first case (semiplane), the boundary stresses are assumed to be given in the form $a(t)f(x)$, the function $a(t)$ being capable of representation by a Mellin integral; $f(x)$ can be represented by the cosine of a Fourier transformation. The potentials of the displacement vector are likewise represented by Fourier transforms with subsequent application of a Mellin transformation. In the case of cylindrical symmetry, Fourier-Bessel transformations are used. The possibility is also discussed of obtaining generalized solutions in the presence of concentrated forces. Further, the case of absence of symmetry in the initial data is investigated. (The general problem of the semispace.) In this case, the same methods are used to construct a formal solution for the scalar and vectorial potentials. Further, a rigorous formulation is given of the constructed solutions, and a proof of certain auxiliary propositions of importance. The mathematical foundation of the rigorous proofs is given by the theory of contour integrals.

It is demonstrated that the method of integral transforms can be used to obtain different forms of one and the same solution, and this circumstance is utilized to elucidate various physical properties of wave fields. I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1809. Mazitov, Sh. S., An experimental verification of the applicability of the wave theory to calculation of machinery parts for resistance to longitudinal (axial) impact (in Russian), *Izv. Otd. Estestv. Nauk Akad. Nauk TadjSSR* no. 13, 65–75, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7062.

Experimental results are given on the verification of the Saint-Venant theory of axial impact on a rod. For the case of the impact of a falling weight on a steel rod fixed at one end, the longitudinal deformations at the fixed end were measured by means of a resistance strain gage and a two-ray oscilloscope. The divergence between the experimental and analytical stress values, calculated by a simplified formula on the assumption that the support and falling weight are absolutely rigid, showed, at impact speeds between 1.40 and 2.42 m/sec, values within the limits of 15–30%. In the combined longitudinal impact (collision) of two steel rods at speeds between 0.88 and 1.98 m/sec, the deviation from the theoretical stress values did not exceed 6%, and from the time values about 8%. Author probably does not know the work of A. N. Dinnik: "The impact and compression of elastic bodies," 1909 [Selected Works, Akad. Nauk USSR, 1952], as well as the paper by B. M. Malyshev [*Vestn. Mosk. un-ta*, 1952, N-5], in which it is found by precision instruments that the divergence in collision time by the Saint-Venant wave theory and the experimental results does not exceed 1.5% for the case of flat butt faces.

V. S. Lenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1810. Shil'krut, D. I., Wave propagation in incompletely elastic media (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 160–163, Apr. 1956.

1811. Funaioli, E., Dynamic behavior of a particular impact machine (in Italian), *Publ. Fac. Ing., Univ. Pisa (16)* no. 771, 9 pp., 1956.

Paper deals with a direct central impact problem regarding the dynamic features of a simplified mechanism. Acting forces are de-

scribed, corresponding equations formulated, and effect of the various parameters analyzed. A numerical calculation is given. With his approach author develops theoretical basis for the design of a new type of plow in which the plowshare works in a discontinuous hammer-like way. H. C. Reggini, Argentina

Soil Mechanics: Fundamental

(See Revs. 1827, 1839, 2122)

Soil Mechanics: Applied

1812. Hoffmann, H., Nomographic design of doubly anchored bulkheads (in German), *Bautechnik* **35**, 2, 59–63, Feb. 1958.

Nomographs are constructed on the basis of Lackner's analytical expressions ["Berechnung mehrfach gestützter Spundwände," Ernst & Sohn, Berlin, 1944] and following Blum's nomographic procedure [*Bautechnik* **27**, p. 45, 1950]. They facilitate the design of the necessary driving depth both for freely as well as for fixed supported bulkheads. Introducing the obtained values into Lackner's formulas, the anchor and toe reactions can be calculated easily. The procedure is applied also for yielding anchors. Four examples are given. L. Suklje, Yugoslavia

1813. Kuzman, P. G., Calculation of the foundation displacements of high buildings in correlation with the results of full-scale observations (in Russian), *Sb. Trudl Mosk. Inzb.-stroit. In-ta* no. 14, 57–115, 1956; *Ref. Zh, Mekh.* no. 6, 1957, Rev. 7242.

Particulars are given of present practice in regard to the design of foundations for high buildings abroad, as well as the fundamental principles for the selection of the foundation soil and design of foundation structures for high buildings on compressible soils in Moscow. A detailed description is given of the characteristics of the engineering and geological features of building sites for high buildings in Moscow, and the calculated values of deformation of foundations are correlated with the results of actual observations. It is found that there is complete agreement between the amount of settling calculated analytically and that observed in the actual case. The calculations have been made on the assumption that the foundation represents an elastic semispace; the moduli of deformation obtained experimentally were between 100 and 50,000 kg/cm^2; the amount of settling was from 6 to 18 cm.

P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1814. Steiermann, I. Ya., The pressure distribution under a foundation in the presence of a plastic region (in Russian), *Sb. Trudl Mosk. Inzb.-stroit. In-ta* no. 14, 32–56, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7126.

A solution is presented for the pressure distribution under a rigid foundation at ground level on the hypothesis that the foundation soil can be represented by an elastic semispace, but that the stresses near the edges of the foundation slab cannot exceed a particular limit owing to the development of plastic deformation in the subsoil. The limiting form of the pressure curve in the regions of plastic deformation, for the exemplary case of the two-dimensional problem, may be assumed trapezoidal, in accordance with V. V. Sokolovsky [*Prikl. Mat. Mekh.* **16**, no. 2, 1952]. This curve determines the maximum pressures along the y positive semi-axis coinciding with the base surface which can be experienced by the foundation without detriment to its stability, in the absence of additional loading along the negative semi-axis.

A similar statement of the problem, but introducing considerably rougher approximations than in the present form of solution, has already been put forward by the abstractor. In this case, the real pressure die is replaced by a narrower die, the width of which coincides with the width of the elastic region of the foundation surface under the real die. The pressures exerted by the real die along two plastic regions near its edges are regarded as an additional load for the conditional die. As an approximation, calculation of the plastic deformations in the soil is completed in this way; in the development of the solution, the entire foundation is considered as a homogeneous, elastic semispace. The friction between the foundation and the pressure die is neglected.

M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1815. Danilova, I. N., Effect of borehole sizes on the bearing capacity of rotors (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 122–123, May 1956.

Processing of Metals and Other Materials

1816. Kobayashi, S., and Thomsen, E. G., Approximate solutions to a problem of press forging, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-140, 11 pp.

The velocity vectors in the flash and body of a press forging of commercially pure lead having axial symmetry were obtained experimentally from incremental displacements in stepwise forging operations. It was found that the velocities are in excellent agreement with those derived with the aid of a simple disk theory, where it was assumed that all deformation is concentrated in a fictitious disk. Comparison with velocities derived from certain slip-line solutions also shows that substantial agreement exists here between theory and experiment.

Calculated average forging pressures, which were obtained by the approximate disk and slip-line theories, are in approximate agreement and the local pressure distributions are similar. These results seem to clarify the role which the flash height and friction in the die-lands play in achieving a good impression of the die cavities. From authors' summary

1817. Takeyama, H., and Usui, E., Study of machinability of metals, ASME Ann. Meet., New York, N. Y., Nov.- Dec. 1958. Pap. 58-A-161, 4 pp.

If the definition of the so-called machinability is simplified, a rather scientific treatment of machinability is possible. The experiment described reveals that machinability of a metal in terms of chip formation, which is one of the most important aspects, is closely related to the ratio of the shearing strain to the shearing stress near the fracture point of the shearing-test curve of the metal. The larger the ratio, the poorer the machinability from the viewpoint of chip formation.

From authors' summary

1818. Frisch, J., and Thomsen, E. G., The effect of process variables on extrusion pressures of lead, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-109, 8 pp.

Billets of commercially pure lead, 2-in. diam × 3 in. long, were extruded at room temperature through five different die contours at ram speeds up to 50 ipm. It was found that, for the direct and indirect extrusions, with good lubrication (white lead in oil) and with good cylinder-wall finish, the extrusion pressure-displacement diagrams were essentially the same. The concentric and eccentric single-bar and multibar extrusions at constant extrusion ratio required approximately the same pressures when extruded at identical speeds. The extrusion pressures overthe wide range of speeds investigated showed approximate linearity when plotted on log-log co-ordinates. From authors' summary

1819. Roth, W., Lassek, H., and Fischer, F., Study on the cold rolling of steel having high carbon contents with sorbitic and pearlitic structure (in German), *Stahl u. Eisen* **78,** 14, 748–955, July 1958.

1820. Kretzschmar, E., Calculation of forces in the roll forming of tube from a steel strip stock (in German), *Technik* **13,** 7, 477–484, July 1958.

As a link in the author's research program on the manufacture of welding rod (in which ferro-alloy welding powder core is covered with tube from a steel strip), roll force and motor power are calculated when the tube cover of the welding rod is formed in five stages by roll-forming process; welding powder is fed into the tube form between the second and third stage. Results of calculations show good agreement with experimental observations. The calculations are based on fully plastic bending moment of steel strip, and are easy to apply and practical. Paper contains a number of obvious but rather confusing misprints.

Y. Yamada, Japan

1821. Miyagawa, M., A general consideration of blank holding in deep drawing of sheet metals, *Bull. JSME* **1,** 1, 95–101, Jan. 1958.

When a circular blank of metal is deep drawn into a cup shape, wrinkles may form around the edge. The progress of deep drawing is measured by the ratio ζ of the initial blank radius to the punch radius. If wrinkles first form at $\zeta = \zeta_{cr}$, the deep drawing is wrinkle-free provided $\zeta_{cr} \leq 1$.

A theoretical method for determining ζ_{cr} as a function of the rigidity C_s of the blank holding system and the holding down force Q is presented. Most efficient deep drawing occurs when, for a given C_s, Q is minimum for which $\zeta_{cr} \leq 1$ (or when C_s is minimum for given Q). Various methods of holding down are discussed (spring, dead weight, fluid pressure, and constant clearance). Theoretical and experimental results are compared and found to be in good agreement.

P. G. Hodge, Jr., USA

1822. Whitton, P. W., The calculation of drawing force and die pressure in wire drawing, *J. Inst. Metals* **86,** 417–421, 1957–1958.

Various wire-drawing theories are examined in the light of recently developed knowledge of the values for the coefficient of friction between the drawn wire and the die. Over the wire-drawing range, the most accurate theories give differences between observed and predicted values of drawing force and mean die pressure amounting to ±20% of the observed values. Those theories which take account of the effect of redundant work, while representing an improvement of those which assume homogeneous deformation, are still unsatisfactory. A new empirical expression permits rapid and simple calculation of the drawing forces over the whole range. It is checked by the observations of three independent investigations and is accurate to within ±10% for wire both annealed and prestrained.

G. Gerard, USA

1823. Tselikov, A. I., Determination of mean velocities of deformation when rolling and drawing metals (in Russian), Prokatnyestany i Tekhnologiya Prokatki, Moscow, Mashgiz, 1955, 7–13; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5958.

S. Ekelund's and N. Kreidlin's formulas ["Calculations for reduction in area when rolling sheets and strips of white metal and alloys," Metallurgizdat, 1950] for the determination of speed of deformation during rolling, where incorrect values were taken for the speed of the rollers, are criticized. The actual velocity of deformation is deduced and the mean velocity is also determined. The formulas of S. I. Gubkin [*Izv. Akad. Nauk, Otd. Tekh. Nauk* no. 1, 1947], Shveikin [Stal', 1953, no. 10] and Nedovizii and Tarnovskii, ["Rapid drawing of low carbon content steel wire," Metallurgizdat, 1954] for the determination of the deformation velocities when drawing were reviewed; here the deformation velocities were determined as a ratio of the degree of area reduction to the time of the metal's stay in the deformation zone. The deformation velocity was determined at each point in the deformation furnace (heat zone), and, based on this, also the mean velocity. By means of a similar method the equation was found for the calculation of deformation speed when drawing pipes on a cylindrical, short or long, mounting.

V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1824. Eggleston, D. M., Herzog, R., and Thomsen, E. G., Observations on the angle relationships in metal cutting, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-138, 17 pp.

Orthogonal-cutting experiments using SAE 1112 free-cutting steel, 2024-T4 and 6061-T6 aluminum alloys, and alpha-brass (85 Cu-15 Zn) at feeds of 0.002 to 0.010 ipr, were performed on a lathe with 18-4-1 high-speed-steel cutting tools. The mean cutting speeds and rake angles for SAE 1112 varied from 33.7 to 170.8 fpm and 5 to 40 deg, respectively, while the remainder of the alloys were tested at conditions yielding a continuous chip without a built-up edge at speeds ranging from approximately 470 to 790 fpm. It was found that the angle λ between the shear plane and the resultant tool force R was only approximately constant for each test condition and varied with cutting speed. Hence the equation $\lambda = \phi + \beta - \alpha = \text{const}$ and the linear relationship between ϕ and $\beta - \alpha$ are only approximately satisfied. Furthermore, neither the Ernst and Merchant minimum-energy criterion nor the Lee and Shaffer nor the Hill ideal plastic-solid solution is in agreement with all the experimental observations.

From authors' summary

1825. Kobayashi, S., and Thomsen, E. G., Some observations on the shearing process in metal cutting, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-139, 12 pp.

It was found that shearing forces on the shear plane were linear functions of the area on which they acted. This was observed for all materials investigated; for SAE 1112 steel, 2024-T4, and 6061-T6 aluminum alloys, and alpha-brass, and also is in agreement with data taken from the literature. Furthermore, all data examined showed that the straight line of shear force F_s versus area A_s intercepted the ordinate at a positive force value. This was interpreted to mean that the intercept part of the shearing force was used up in overcoming workpiece deformation or friction at the flank of the tool and was not available for chip deformation. Accepting this concept, it can then be shown that the average shearing stress on the shear plane for SAE 1112 is constant and is independent of normal stress, cutting speed, or strain rate, extent of deformation or finite strain, and extent of prior deformation. The shearing stresses for the other materials tested or examined were also constant for the limited range of variables available.

In contrast to the shearing stress, the normal stress on the shear plane was not constant and appears to be a yet unknown function of the mechanism of friction on the tool face.

The shearing stresses calculated from the metal-cutting data showed good correlation with flow stresses at the same finite strains which were obtained from static compression tests. The reason for the uniqueness of the finite strains at which correlation is achieved is not as yet clear.

From authors' summary

1826. Christopherson, D. G., Oxley, P. L. B., and Palmer, W. B., Orthogonal cutting of a work-hardening material, *Engineering* **186,** 4820, 113–116, July 1958.

Paper commences by reviewing existing prominent orthogonal cutting theories and highlights weaknesses therein. A new semi-empirical (but plane strain) approach is described based upon

practical observations of the slow-speed cutting operation, cine-filmed through a microscope. Experimental conditions are regrettably not fully described but outlined and the mode of deformation is shown to disagree with the assumption of an ideal plastic rigid solid. New approach accepts a variable yield stress with strain and by using other simplifying assumptions, e.g. no variation of yield stress on a slip line, reasonable equations are built up. Inconsistencies are pointed out and explanations advanced which have been carefully thought out.

Reviewer was left with the impression that the major disadvantage of the method was its limitation when applied for normal and high cutting speeds, but this original approach may well be extended. P. W. Whitton, England

1827. Fishwick, W., and Tobias, S. A., Machine tool chatter—effect of flexibility in machine and foundation, *Engineering* **185,** 4808, 568–572, May 1958.

1828. Krabacher, E. J., Factors influencing the performance of grinding wheels, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-40, 7 pp.

Fracture (Including Fatigue)

(See also Rev. 1732)

1829. Uemura, M., On the fracture of metals, *Bull. JSME* **1,** 1, 7-12, Jan. 1958.

An empirical procedure for analysis of fracture tests in terms of hydrostatic tension and maximum shear strain is discussed and applied to selected test results. A resumé is given of author's tensile tests on round bars of low-carbon steel which were reduced to a fixed area by circumferential notches of various acuity. In tests such as those discussed load increase is first limited by action of the plastic flow pattern. Subsequently, fracture develops at a macroscopic apparent plastic strain which is less when the hydrostatic tension is greater. Author's fracture criteria, one for tensile fracture and one for shear fracture, assume maximum shear strain related to hydrostatic tension by linear equations.

Author's analytic procedure is complex. Reviewer felt the expected decrease of plastic shear strain with increase of hydrostatic tension could have been given a simpler presentation.

G. R. Irwin, USA

1830. Delle, V. A., and Noskin, A. V., Influence of high-speed loading on the tendency of constructional alloy steel to brittle disruption (in Russian), *Trudi Leningr. Korablestroit. In-ta* no. 15, 96-108, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6178.

Authors set themselves the objective of verifying the existing representations that the influence of high velocities is of equal value (the authors for some reason or another do not accept the necessity of using this word instead of the synonomous "equivalent") to the influence of low temperatures, pointing out the part played by inertia phenomena and the adiabetic nature of the impact process, absent at low temperatures. The experiments were carried out on a special pneumatic hammer appliance made by the Leningrad Ship Building Institute [see A. V. Noskin et al., *Zavod. Labor.* no. 8, 989–994, 1952] for tension at impact rates of 75 to 100 mps and for bending with notches at speeds of up to 200 mps. At the same time tests were carried out for destruction on Gagarin's press and for impact bending (apparently on the usual press) at lowering temperatures (~ through 25°) with determination of impact viscosity. Investigations were made on 19 different types of alloyed steel (with different additions of Ni, Mo, Cu, Mn) in the drawing condition (560–680°), after annealing, possessing approximately the same hardness (H_B = 217 – 248).

Tests for tension at room temperature showed that the relative elongation by impact in all cases exceeds that by static loading (in round figures 80% of the relative), apparently because of the tendency to form two necks. Here a change of velocity from 75 to 100 mps also makes itself felt on the elongation, although to a small degree (with the limits of 6% of the relative). A much smaller influence of speed is shown on the constriction of the transverse section; here the transition to impact alters the constriction on an average from 65 to 70%. When tested for high velocity bending after notching all of the steels (with the exception of the Mn alloy) showed also some increase of viscosity (evaluated by the deformation characteristics) when velocities went up from 100 to 200 mps; only one steel with 2.97% Mn content gave a lower figure: 0.75 at 100 mps; 0.61 at 150 mps and 0.59 at 200 mps (in conditioned units). Steel with 1.45% Mn showed equal viscosity at velocities of 100 and 200 mps. The rest of the alloys gave an increase of 5–10%. At the same time the impact velocity at diminishing temperatures for all the steels without exception showed continuous lowering, starting even at –50°; at this point the manganese steel even at –50° broke with a brittle fracture (fall of the impact viscosity from 11.0 to 1.5 kg/cm²). From this the authors deduce that the influence of high-speed and low-temperature tests are directly contradictory, which conflicts with the theory of their equal value. Consequently this theory requires serious redefinition.

In the abstractor's view, the contradiction revealed should apparently be explained by the circumstance that, with the exception of Mn steel, for all the remaining steels speeds of even 200 mps were below the speeds corresponding to the upper threshold of cold fracture; in the viscous state the increase of velocity leads to the heightening of the work of deformation, and also of plasticity because of the heightening of the resistance to deformation and disruption and also, possibly, because of the adiabetic heating.

N. N. Davidenkov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1831. Shepard, L. A., and Giedt, W. H., Transgranular and intergranular fracture, *NACA TN* 4285, 16 pp. + 2 tables + 8 figs., Aug. 1958.

Creep tests were performed on ingot iron at temperatures from 700 to 1350 F to find whether the amount of grain-boundary sliding determined the fracture mode (transgranular or intergranular). If the mode were thus determined, a critical stress rather than a critical temperature would be the criterion for intergranular fracturing. Transgranular fractures were obtained below 800 F and above 20,000 psi. At higher temperatures, all fractures were intergranular. Tests indicated that intergranular fracturing may occur without grain-boundary shearing in the lower temperature range. It was concluded that a vacancy-condensation mechanism is most probably responsible for high-temperature intergranular fracturing in ingot iron. From authors' summary

1832. Kihara, H., and Masubuchi, K., Effect of residual stresses on brittle fracture—studies on brittle fracture of welded structure at low stress level (in Japanese), *J. Soc. Nav. Arch. Japan* **103,** 251–262, July 1958.

Present authors tried an experimental investigation of residual stress on brittle fracture and clarified the fact that residual stress may have an important effect on brittle fracture. The main results obtained are summarized as follows:

(1) When the testing temperature is high enough to produce shear fracture, fracture stress is very high and residual stress has no effect on fracture stress.

(2) When the temperature is below the fracture transition temperature but above the arresting temperature of base metal, brittle crack may be produced under low applied stress. But the crack will be arrested after running a certain length, and complete frac-

ture of joint is produced at high stress level (nearly equal to the yield stress). Thus, the existence of residual stress produces no effect on the load-carrying capacity of welded structure.

(3) When the temperature is below the crack-arresting temperature, brittle crack will be initiated at low stress, and, in this connection, two different cases will occur according to the level of applied stress at the crack initiation:

(a) If the level of applied stress at crack initiation is lower than the value of critical stress of brittle fracture, the crack will be arrested after running a certain distance, and the final fracture stress will be as high as yield stress of the base metal. Consequently, the final fracture strength of welded joint is not affected by the existence of residual stress.

(b) If the level of applied stress at crack initiation is higher than the value of critical stress, the crack will propagate through the whole width of material, and the welded joint will fail in single stage at low stress level. In this case, the existence of residual stress has a serious effect on the load-carrying capacity of welded structure. From authors' summary by T. Kanazawa, Japan

1833. Wright, H. R., The effect of temperature on bursting discs, *Trans. Instn. Chem. Engrs.* **36,** 2, 69–78, 1958.

Report gives the results of an investigation into the effect of temperature on the bursting pressures of disks of various materials. The materials include aluminum, copper, nickel, Monel, 18/8/Ti steel, mild steel, silver, platinum, and palladium.

Tests have been carried out over the temperature range –80 C to +400 C but no material was tested over the whole range. With one exception (mild steel) all the materials show steady falls in bursting pressure with the rise of temperature (e.g. between 10% and 50% from room temperature to 250 C.)

The tests have shown that Monel possesses advantages over most bursting disk materials in that it suffers only a moderate fall in strength with rise of temperature, and it has, of course, good resistance to corrosion by wide range of fluids.

Apart from the falls of bursting pressure under conditions of rapid testing, further falls are possible under conditions of prolonged application of pressure. To allow for both of these effects limits must be set to the pressure to which a disk should be exposed under operating conditions, and advice is given on this aspect. From author's summary

1834. Philip, T. B., The effect of temperature on bursting discs, *Trans. Instn. Chem. Engrs.* **36,** 2, 79–80, 1958.

The effect of temperature on bursting pressure of disks made from foils of seven different materials is indicated graphically. Creep failure of the more ductile metals at temperatures much above room temperature is so marked that the results indicated are of limited practical significance.

From author's summary

1835. Brown, J. F. W., The effect of operating temperature on the bursting pressure of some materials commonly used for bursting discs, *Trans. Instn. Chem. Engrs.* **36,** 2, 81–86, 1958.

A method of testing bursting disks at temperatures above and below ambient is described, and the results of a large number of these tests are tabulated and discussed.

From author's summary

1836. Lundberg, B. K. O., Some proposals for evaluating fatigue properties of airplane structures (in English), *Flygtekn. Försöksanst. Medd.* **76,** 36 pp., 1958.

There is a need for systematization both of fatigue test results, be they of the common S-N or of the increasingly important spectrum type, and of concepts pertaining to spectrum fatigue properties, and there is also a need for clarification of the concept of safety with regard to fatigue. For these purposes some definitions and methods of evaluation of fatigue qualities are proposed. The most important proposals are a definition of a "unit load-spectrum period" and the expression of spectrum fatigue life in terms of a "spectrum life multiple," defined as the number of times that the unit spectrum period is repeated, for instance until failure or a certain probability of failure. With these concepts as a basis, methods are presented for the design of a structure—the *S-N* data of which can be assumed—for a required spectrum life, and proposals are made for presentation of spectrum properties as obtained by spectrum fatigue tests.

Methods for direct determination of the parameters of the *S-N* equation are given and some results are discussed. A three-parameter equation for spectrum fatigue life, corresponding to the *S-N* equation, is further proposed and theoretical relationships between the parameters of the two equations are deduced. Results from spectrum testing thus can be expressed as fictitious *S-N* parameters.

The method of relating stresses and loads to the ultimate strength is again advocated, as well as the method of expressing, by a "fatigue factor" k_A, the reduction in stress level—from that corresponding to static strength requirements—needed to assess required fatigue properties. It might be pointed out, however, that adoption of these methods is not necessary for the employment of the other proposals of the report.

With respect to safety the concept of a "limit fatigue factor", k_{A50}, is proposed as distinct from safety factors covering scatter. It is maintained that rational design for fatigue cannot be achieved by applying generally prescribed safety factors, as the magnitude of such factors would have to vary within extremely wide limits depending on the type of structure (statically determinate and fully "fail safe" structures being the two extreme cases) and its scatter in fatigue strength. Designing to a certain low failure rate is therefore further advocated as a method applicable for all types of design. From author's summary

1837. Minami, Y., and Fukuda, Y., Stress-corrosion of mild steel. (III) Fatigue strength of mild steel plate after stress-corrosion or cathodic protection, *Bull. Fac. Engng., Yokohama Nat. Univ.* **7,** 23–32, Mar. 1958.

Fatigue tests on the specimens of a mild steel plate after stress-corrosion or cathodic protection in sea water at several stresses and the time of immersion were carried out.

In the stress-corrosion tests, the fatigue limits after stress-corrosion slightly decrease with the increase in applied stresses during corrosion. Although the fatigue limit, without distinction of the magnitude of stress, after corrosion of three months is nearly equal to that in the air after immersion of five months or more, it decreases about 10% lower than the latter. The decrease in strength after corrosion of five months will be due to the appearance of corrosion pits.

From the tests under cathodic protection it is concluded that the fatigue limit will not be influenced by the applied stress or the time of immersion in sea water if the impressed current is suitable for the potential to be enough to protect corrosion.

From authors' summary

1838. Meshchaninov, I. A., "Friable" disruptions in the seams of boiler units (in Russian), Improving the reliability and economy of working boiler units, Minsk, Izd-vo Akad Nauk. BSSR, 1954, 39–63; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6117.

The reasons are examined for the friable breakdown of boiler parts which takes place in the presence of three conditions: (a) high local tension stresses; (b) the washing of a stressed layer of metal with a highly concentrated solution of erosive alkali, which forms in the clearances because of evaporation; (c) the action of high temperature and pressure. The breakdown has the character of intercrystalline corrosion and appears along the periphery of the granules. Practical examples are given of the destruction of rivets, expanded tube ends, boiler plates and cylinder shells.

measures are suggested to prevent the occurrence of the three types of breakdown indicated. B. A. Drozdovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1839. Medvedev, K. S., On the theory of rock slip (in Russian), *Izv. Akad. Nauk KazSSR* no. 3, 76–82, 1954; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7142.

The fault planes in rock masses are investigated as the sources of diminished stability, from data on the sinkage of surfaces and records of fault cracks.

A classification of tectonic cracks is presented as well as of fault cracking, based on their orientation to the fundamental structure of an ore deposit. The conditions of limiting equilibrium are investigated, and equations are derived defining the relationship between the physical and mechanical constants of rocks in monolithic form, and the forces of friction and cohesion acting in the plane of the fault. These equations determine the minimum angle of a crack plane.

Author is of the opinion that the stronger the rock, the flatter are the fault planes at which slip is possible, which is confirmed by observations in the Krivoy Rog field.

K. K. Glazenap

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Experimental Stress Analysis

(See Revs. 1756, 1764, 1829)

Material Test Techniques

(See also Revs. 1811, 1859)

1840. Poluboyarinov, D. N., and Volosevich, G. N., Methods of determining the bending strength of ceramic materials (in Russian), *Trudi Mosk. Khim.-tekhnol. In-ta* no. 21, 80–85, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7372.

Determination of the strength of ceramic and metal-bonded ceramic materials is one of the most important methods of evaluating the quality of these materials, and a convenient check on the correctness of the manufacturing technique used. As a method of control, determination of the mechanical strength differs favorably from the method of determining the specific weight by its greater sensitivity, while it surpasses the method of structural investigation by its greater speed and simplicity of application.

The examples quoted in the paper show that the strength of a corundum ceramic is directly associated with its chemical composition and crystal size. Paper pays principal attention to the methods of strength testing, with a view to their simplification and increasing accuracy. In particular, the simplest method suggested for strength-testing ceramics is the bending test under a concentrated load applied between two supports. This method is more convenient than tension or compression tests, or pure bending if the sample is of small dimensions.

B. P. Pribylov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1841. Ginzburg, Ya. S., Simplification of relaxation tests on metals and alloys (in Russian), *Zavod. Lab.* **22**, 7, 840–845, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7367.

A method is suggested for plotting relaxation curves for different stress levels from the curves for two or three initial stresses at constant temperature by virtue of the fact that, for the second stage of relaxation, the logarithmic ratio for all metals and alloys is rectilinear in character. G. A. Tulyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1842. Pamfilov, V. V., A method of evaluating the work and deformation of a timber sample in impact testing (in Russian), *Zavod. Lab.* **22**, 3, 333–334, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3763.

1843. Geil, G. W., and Carwile, N. L., Research on effects of prestraining and notch sharpness on the notch strength of materials, WADC TR 56-402 (PB 121782; ASTIA AD 110436), 15 pp. + 13 tables + 72 figs., Oct. 1956.

A general study was made on the effect of prestraining in tension at +25 C on the tensile properties at −196 and +100 C of notched and unnotched specimens of (1) a commercially pure titanium, Ti-75A, and (2) a 4% Al, 4% Mn titanium alloy, Cl30AM. Included in this general study were (1) a preliminary investigation on both materials to determine the effect of the notch sharpness, as varied by a change in root radius or notch depth, on the tensile properties, (2) a study of the combined effect of notch sharpness (as varied by a change in notch depth) and prestrain at +25 C on the tensile properties of notched specimens of these materials at −196 or +100 C, and (3) a determination of the impact properties of Charpy V-notch specimens of both metals over the temperature range of −196 to +300 C.

Prestraining in tension at +25 C had considerable effect on the ductility retained by both the notched and unnotched specimens of each material at −196 or +100 C. Furthermore, the retained true strain at initial fracture (total true strain at initial fracture in the second stage of test at −196 or +100 C minus the true strain at the end of the first stage of test at +25 C) decreased with increase in the prestrain at +25 C. The results indicate that Ti-75A and Cl30AM are not subject to "rheotropic embrittlement," as the retained ductility of the specimens at −196 C was not improved by prestraining at +25 C.

Prestraining in tension at +25 C had little, if any, effect on the tensile strength or notch strength of Ti-75A or Cl30AM, except for some impairment in the notch strength of the deep-notched specimens of Cl30AM that did not retain any appreciable ductility at −196 C.

The change from a ductile to brittle behavior in the impact tests on Charpy V-notch specimens (based on the energy absorbed in fracturing the specimens) occurred over temperature ranges of approximately −150 to +100 C and −200 to +100 C for Ti-75A and Cl30AM, respectively. From authors' summary

1844. Zilova, T. K., and Fridman, Ya. B., Mechanical tests with variable pliability of loading (in Russian), *Zavod. Lab.* **22**, 6, 712–717, 1956; *Ref. Zh. Mekh.* no. 4, 1957; Rev. 5077.

1845. Machida, S., Study on some effects on Shore hardness number, *Bull. JSME* **1**, 1, 30–35, Jan. 1958.

1846. Braun, A., Measurement of hardness: principles, theories, and methods (in German), *Schweiz. Arch.* **24**, 4, 105–133, Apr. 1958.

This paper is the first one of a series on the principles of materials testing, to be published by the "Schweizerischer Verband für die Materialprüfungen der Technik" (Swiss Soc. for Testing Materials). Papers will have a thoroughly basic nature in order to obtain a common basis for related technical applications. Starting from a general definition of hardness, author considers in a rather comprehensive way different types of variables regarding the geometry of the indentation, the deformation process and the characteristics of materials. Several types of rheological

behavior of the material are included. Different hardness concepts and methods for hardness measurements are outlined. Attention is drawn to the empirical nature of technical hardness tests. Testing methods and applications are discussed from a basic point of view.

Reviewer feels that this paper offers a comprehensive survey of concepts, principles and appreciations in a rather academic way. It therefore should be studied by those who have a basic interest in the hardness concept as a material property.

J. Schijve, Holland

1847. Roitman, I. M., Development of the micromechanical method of testing metals (in Russian), *Zavod. Lab.* **22**, 7, 834–840, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8512.

The principal schemes and special features of existing machines for micromechanical tests were investigated. It was shown that the most important requirement in the micromachine was the guarantee of sufficiently high hardness, the absolute value of which should be larger than that of the sample under test. A short account of the advantages and shortcomings of machines such as Shovenar's, the Amsler firm's Mi-34, the "Instroin" (SSZA) and the home-produced RF. It was pointed out that micromachines RF, released in a small number as an experimental issue, were used for carrying out a significant number of investigations, in-conjunction with which the gradual manufacture of the perfected machine proceeded. From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1848. Keinath, G., The measurement of thickness, *Nat. Bur. Stands. Circ.* 585, 79 pp., Jan. 1958.

The numerous methods for the measurement of thickness in laboratory or shop are treated in seven groups according to physical operating principles: Mechanical—weight/dimension relationships, acoustics, vibration, displacement with various conversions; chemical—stripping, spectrochemical analysis; electrical—dielectric breakdown, resistance, electrochemical, capacitance, thermoelectricity; magnetic—attractive force, reluctance, saturation, inductance, eddy currents; optical—microscopy (also electron microscopy), interferometry, diffraction, shadow; X-ray—absorption, diffraction, backscatter, spectrometry; radioactive radiation—absorption, backscatter, tracers. Ranges, accuracies, advantages, and limitations are discussed. A bibliography of references, a limited list of suppliers, and a detailed index of the gages, methods, applications, and trade names covered are appended. From author's summary

1849. Barsch, K. N., and Meisel, M. M., A new experimental method for determining the creep limit (in Russian), *Nauch. Trudi Mosk. Tekhnol. In-ta Legkoy Prom-sti* no. 7, 80–92, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7400.

Usually, in order to determine the creep limit of high polymers under multilateral compression, the pressure is measured at which deformation commences by extrusion through a capillary tube or die. More objective results are obtained if the pressure is recorded, not for the beginning of flow, but at termination. A drop in pressure has been observed in a cylinder filled with a rubber compound precompressed by a subsequently fixed plunger. The pressure was measured by an inductive gage with an accuracy within 2%. In one variant the cylinders had no exit, and the pressure drop took place only because of relaxation of the three-dimensionally compressed material, as expressed by the following equation:

$$\sigma = \sigma_o + (\sigma_H - \sigma_o) \exp(-t/t_p),$$

in which σ_H is the initial stress, σ the stress after the time interval t, σ_o the limiting stress, and t_p the relaxation time. The relationship $(\sigma_H - \sigma_o)/\sigma_o$ is in the general case greater with smaller σ_H, and for the rubber compounds investigated was within the limits of 10–25%. In another variant, the cylinder had open passages, and the pressure drop was conditioned by the combined effect of relaxation and plastic flow. Analysis of the process showed that in these conditions the pressure under the plunger asymptotically tends to the value of the creep limit. The relationships established have been confirmed experimentally. For two rubber compounds the pressure stabilized at values of 6.0 and 8.5 kg/cm² within 115 and 135 hours, respectively.

L. S. Frumkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Properties of Engineering Materials

(See also Revs. 1745, 1748, 1749, 1750, 1842, 1843, 1846, 1849, 1900, 2168)

Book—1850. Grange, R. A., Shortsleeve, F. J., Hilty, D. C., Binder, W. O., Motock, G. T., and Offenhauer, C. M., Boron, calcium, columbium, and zirconium in iron and steel, New York, John Wiley & Sons (New monograph series), 1957, xiv + 533 pp. $14.

Title of book is somewhat misleading as involved alloying elements treated are five instead of four, tantalum being treated within the section mainly devoted to columbium (niobium). That, however, might be quite correct considering the close relationship between these two metals, of which columbium nowadays is the more important. The book is prepared in order to give a handy compilation of published data and reports of experimental work, some of which have not been published before, and the condensed form of information is given the reader mainly as a rapid-working key to worldwide literature items scattered in a lot of different papers. Reviewer thinks that this aim is duly reached and that most parts of the treatment are quite far from the usual boredom which often is integrated within books of this special kind. Book might even be read by ordinary metallurgists and engineers in order to improve their judgment on practical metal alloy problems.

The four sections of the book, in reality four separate treatments, are in general logically prepared the same way: historical review of base facts, facts about minerals and ore, preparation of metal, physical properties of metal, preparation of alloys and properties of alloys, metallographic studies, alloying effects on steel and iron of different types, engineering properties of commercial steels under different manufacturing procedures. Quite naturally the major part is that devoted to columbium, as the effect of Cb alloyment on ferritic Cr-steels and austenitic Cr-Ni-steels as well as on gas turbine alloys of different kind is of greatest technical and commercial interest. The steadily increasing interest in boron and zirconium alloyment in steels and iron for special machinery and structures will in a few years result in a superfluous literature. The items quoted in reviewed book give a good basic conception of what is to come on these points, and will surely help the engineer to make a good choice.

Each section contains an extensive bibliography and a name index, which refers both to item numbers of bibliography and to page number of quotation. Furthermore, a subject index covering the whole volume contains more than 1000 items. Each bibliography section covers published articles from different countries up to year 1956. It is, however, obvious that rather many reference sources are overlooked, especially those of Russian origin.

R. Nilson, Sweden

Book—1851. Bickel, E., The metallic materials in machine construction [Die metallischen Werkstoffe des Maschinenbaues], 2nd ed., Berlin, Springer-Verlag, 1958, xii + 439 pp. DM 37.50.

The great number of metallic materials aggravates a selection of a suitable material for the construction and production of a struc-

tural part by the engineers or designers. If the designer does not have an expert on materials as consulting engineer at his disposal, he must know the bases of the scientific metallurgy, the physical-chemical composition of the metals, especially, in order to estimate their behavior under practical service conditions. Author's aim is the presentation of a summarized introduction in the field of general and special metallurgy and of the testing of materials.

Book is divided in four main parts. Part I deals with the scientific fundamental principles of the structural constitution. Here author describes the crystalline structure in connection with x-ray studies and discusses the bonding properties in crystals, the chemical compounds, the formation of solid solutions, the structure patterns and structure defects. Part II contains the details on the alloying science. This part begins with the general properties and the structural constituents of the alloys and includes the constitutional diagrams, phase science and the atomistic consideration of the alloying formation. Part III is of great importance for the practical engineer because this section deals with the technological and physical properties of the materials and testing methods. Part IV contains the special metallurgy. Above all, here are described the ferrous metals, e.g. iron, steel, cast iron, malleable cast iron, and the methods of heat treatments. Furthermore, there are briefly discussed the most important types of nonferrous and light metals, bearing metals, materials for resistors, and sintered materials.

The book is written by an engineer who has an experience of long standing in the designing practice, production, research and academic science. Therefore, this textbook represents a good combination of scientific basic research and practical evaluation. An intensive study of this book, written in a good style and containing numerous tables, drawings and photographs, provides students and engineers with information on the metallic materials used in mechanical engineering.

M. Hempel, Germany

1852. Connolly, B. J., and Boyd, G., The high temperature properties of four wrought steels used in the chemical industry, Instn. Mech. Engrs., Prepr., 15 pp.

Paper presents data on the short-time high-temperature tensile properties and creep properties of four steels which are in common use in the chemical industry, these data having been recently obtained from tests done at the Imperial Chemical Industries (I. C. I.) Creep Test Station. The steels tested were:

(1) low-carbon 1% chromium-molybdenum (Cr-Mo) steel;
(2) medium-carbon 1% Cr-Mo steel;
(3) low-carbon 3% Cr-Mo steel;
(4) 18/10/Mo/Ti chromium-nickel (Cr-Ni) austenitic steel.

Information is also given on the effect of long-term heating under stress on the microstructure of the steels; in the case of the austenitic steel, the effect on the room-temperature mechanical properties is discussed. The application of the data to design and their relation to existing specifications is also discussed.

From authors' summary

1853. Turnbull, J. C., Tension stresses in glass coatings and in glass-metal seals in the annealing range, *J. Amer. Ceram. Soc.* **41,** 9, 372–376, Sept. 1958.

The strength of glass coatings applied to metals was found to decrease with time at temperatures in the lower annealing range. This decrease is caused by the well-known decrease in volume which glasses undergo at these temperatures. Glasses applied to a metal surface are constrained in directions parallel to the surface, and the decrease in volume thus produces tension strains in these directions. In this temperature range, the production of tension stress due to density increase is partly offset by stress release due to viscous flow. These effects, calculated from measurements of density variation and of stress release in the glass used for coating, were found to indicate variations in glass strength which agreed approximately with values measured by a cross-bending test. Significant tension stresses of similar origin were observed to appear in glass-metal seals during baking in the lower annealing range.

From author's summary

Structures: Simple

(See also Revs. 1698, 1752, 1768, 1795, 2124)

1854. Cox, H. L., The application of the theory of stability in structural design, *J. Roy. Aero. Soc.* **62,** 571, 497–519, July 1958.

This lecture before the Royal Aeronautical Society presents a running account of certain minimum weight approaches to the design of structures subject to instability. Lightly treated are multiweb beams and multiweb-stringer construction, frame-stringer and honeycomb sandwich construction. A more complete discussion follows on the interaction between primary instability modes of bending and torsion and between local instability and torsion. Finally, brief conclusions are drawn as to the comparative efficiencies of the various forms of construction considered in terms of a pertinent loading index.

Because the broad subject of minimum weight analysis is presented in about 10 pages, the reader may find considerable difficulty in following the brief treatment. Two other investigators apparently required book-length treatments of this subject to present the theoretical development in reasonable detail.

G. Gerard, USA

1855. Lee, S. L., The conjugate frame method and its application in the elastic and plastic theories of structures, *J. Franklin Inst.* **266,** 3, 207–222, Sept. 1958.

The basic concept of the conjugate beam method of analysis is extended to cover applications in two dimensions. For a given real frame a conjugate frame is obtained and "loaded" with the angle changes which occur in the real frame. The moment of this "loading" is shown to be equivalent to the deformation of the real frame. For elastic action M/EI represents a distributed conjugate loading; for plastic action the rotation at a plastic hinge represents a concentrated conjugate load. Indeterminate frames are considered and numerical examples are given. Reviewer observes that this subject has been treated in great detail by the late J. S. Kinney in "Indeterminate Structural Analysis," Addison-Wesley, 1957 [AMR **11** (1958), Rev. 2566]. E. R. Johnston, USA

1856. Gerstle, K. H., Analysis of braced frames, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 2 (*J. Struct. Div.*), Pap. 1560, 11 pp., Mar. 1958.

Method of analysis for knee-braced frames is presented that is analogous to the familiar moment-distribution method of rigid frame analysis. The needed factors are given and the procedure is illustrated by a solved example. Method would appear to have advantages in some cases over customary procedures.

From author's summary by R. J. Roark, USA

1857. Klein, B., Application of the Witte rearranging method to a typical structural matrix *J. Aero. Sci.* **25,** 5, 342–343 (Readers' Forum), May 1958.

Author proposed in previous publications to solve structural problems by setting up all possible equations in forces and displacements. Inevitably a very large and unsymmetric matrix has then to be inverted. To obviate the associated difficulties it is suggested now to rearrange the matrix of the coefficients, using a device due to Witte, in order to obtain a matrix approximating as closely as possible a triangularized form. Solution is then much simplified and involves first the completion of the triangularization. Author believes that this approach is possible in complex structural systems.

J. H. Argyris, England

1858. Laulo, Kh. Kh., The calculation of spherical ferroconcrete vaults (in Russian), *Trudi Tallinsk. Politekhn. In-ta* **A,** 65, 14–25, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7248.

An approximate method is suggested for the calculation of a spherical ferroconcrete vault having closely spaced meridional cracks in the vicinity of the supporting ring.

Problem is examined on condition of axial symmetry with the load uniformly distributed over the surface of the vault. The solution is arrived at by means of a calculation of the statically indeterminate systems by the method of forces.

Results are presented of a numerical calculation of a vault; curves of the bending moments and annular forces are presented; and a chart of the fundamental calculation parameters is given.

A. N. Elapt'evskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1859. Plywood folded plate roofs, a tenative design method, Douglas Fir Plywood Association, Technical Dept., 31 pp., Nov. 1958.

Tentative design methods and fully detailed design examples are presented for single-bay and multiple-bay folded plate roofs consisting of timber frames and plywood skins firmly nailed to the framing to act as diaphragms.

Common wire nails of 2½-in. and 3-in. lengths are spaced from 1-in. to 6-in. on centers along the plywood edges and 12-in. on centers over intermediate supports of the plywood. This close spacing results in the use of a large amount of nails as well as of time required for nailing of the diaphragms. In reviewer's opinion, the required amount of nails can be reduced 36%, without reducing the number of nails, and the required amount of labor can be reduced slightly by using, for instance, instead of the 2½-in. common wire nail, the 40% shorter 1½-in. × 0.135-in. threaded nail with small lead angle as described in V.P.I. Wood Research Laboratory Bulletin no. 35 on "Nailing of plywood sheathing with 'hi-load' nails."

E. G. Stern, USA

1860. Biggs, J. M., Wind forces on structures: introduction and history, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1707, 5 pp., July 1958.

1861. Sherlock, R. H., Wind forces on structures: nature of the wind, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1708, 17 pp., July 1958.

1862. Singell, T. W., Wind forces on structures: forces on enclosed structures, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1710, 25 pp., July 1958.

1863. Woodruff, G. B., and Kozak, J. J., Wind forces on structures: fundamental considerations, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1709, 14 pp., July 1958.

1864. Watters Pagon, W., Wind forces on structures: plate girders and trusses, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1711, 30 pp., July 1958.

1865. Farquharson, F. B., Wind forces on structures: structures subject to oscillation, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1712, 14 pp., July 1958.

Structures: Composite

(See also Revs. 1735, 1836, 1838, 2040, 2104, 2154)

Book—1866. Steinman, D. B., and Watson, Sara Ruth, Bridges and their builders, New York, Dover Publications Inc., 1957, xvi + 401 pp. $1.95 (Paperbound)

1867. Naruoka, M., and Yonezawa, H., Application of the bending theory of orthotropic plates to the analysis of skew girder bridges (in German), *Bauingenieur* **32,** 10, 391–395, Oct. 1957.

The classical bending theory of orthotropic plates is applied to the analysis of a skew girder bridge with two opposite edges free and the other two edges simply supported. The governing differential equation is solved by the method of finite differences. Numerical results for the bending moments are checked experimentally by the use of a model bridge, and the agreement is found satisfactory.

Y.-Y. Yu, USA

Book—1868. Collected papers of the Faculty of the Building Department, School of Railroad Engineering, Vol. I [Fakulta Stavebni Sbornik Vysoke Skoly Zeleznichi], Praha, Dopravni Nakladatelstvi, 1957, 143 pp.

Of the six papers by faculty members of the School of Railroad Engineering presented in this volume three deal with specific problems related to the design of railroad bridges (V. Dorak, Safety of welded railroad bridges; J. Horejsi, Deflection of continuous beams with fieldwise constant moments of inertia; V. Kolusek, Dynamic effects in reinforced-concrete railroad bridges), two are concerned with problems of planning of locomotive sheds (A. Skrbek) and of water protection of the roadbed (P. Tye), while the last and longest paper (50 pages), by J. Korouz, is concerned, quite surprisingly, with the asymptotic behavior of orthogonal polynomials; two theorems concerning asymptotic properties are developed which represent extensions of well-known theorems of Szego.

Only the papers on dynamic effects in bridges and on asymptotic polynomials are contributions representing research of some originality. The particular significance of the first of these papers is in the attempt to correlate the results of theoretical analysis with actual records of bridge oscillations under locomotives travelling at different velocities.

A. M. Freudenthal, USA

1869. Dabrowski, R., On the computation of curved bridges with open cross sections (in Polish), *Rozprawy Inz.* **5,** 2, 227–239, 1957.

The aim of this paper is a simplified derivation of Gottfeld's formulas.

Author considers a three-dimensional single-span lattice uniformly curved in the horizontal plane. Its active load, consisting of one vertical concentrated force, is resolved into a component load in the form of a concentrated force, attached to the center of curvature of the system, and a couple acting in the cross section passing through the point of attachment of the force. Thus formulas for bending moments and transversal forces in vertical walls of the system are obtained. These can be used for suitable wall systems.

In the final part of the paper the computation of a three-span continuous system, curved in the horizontal plane, is presented.

J. Czulak, Poland

1870. Ferry Borges, J., Marecos, J., and Cunha Ferraz, L., On the evaluation of the safety of old metallic bridges (in English), *Minist. Óbras Publ., Lab. Engen. Civ. Lisboa, Tech. Pap.* 105, 21 pp., 1957.

Book—1871. Latyshenkov, A. M., Current-regulating dams (in Russian), Inform. Materialy Vses. N.-i. In-ta Vodosnab., Kanaliz., Gidrotekhn. Sooruzh. Inzh. Gidrogeol. no. 1, 196 pp. + illus., 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6698.

Laboratory and full-scale experiments are described on the selection of the contour and the calculation of current-regulating dams in artificially constricted channel cross sections: at bridges,

dams and weirs. Chapter I examines existing calculation methods and planning of training walls for bridge passages.

Chapter II contains abbreviated results of observations on the condition of the retaining wall in four bridge passages over the lowland and foothill sections of rivers.

In chap. III the methods of calculating the velocity of a constricted flow are examined: laboratory investigations are described, made by the author in the Kuchino hydraulic laboratory, on the velocity distribution in such a case. Author states approximate relationships between the flow velocity increments in the channel and the overflow after erection of the bridge passage, as well as formulas for calculating the width of the bridge aperture; curves are given for determining the coefficients contained in the said formula.

Chapter IV describes laboratory investigations on the pattern of flow at a unilateral retaining wall of five different outlines. The width of the overflow in the model was 4 meters, of the channel 0.4 meters; flow volumes, 23.9 and 38 l/sec with depths in the overflow of 3-4 cm, and in the channel 7-8 cm. The majority of the experiments were made on a model, and a few on a model exposed to scouring.

The best flow conditions without separation, centrifuging or reverse flow were found in retaining walls with curvatures smoothly increasing from the head to the bridge section (elliptical forms with a ratio of axes between 1.5 and 2).

Experimental investigations on retaining walls at an overflow weir of a large hydraulic power station and at the flumes are described in chap. V.

Chapter VI contains a calculation and method of construction of retaining walls of elliptical outline for the reaches of lowland rivers.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1872. Slobodyan, R. T., Application of V. V. Sokolovskii's method for the calculations of the stability of earth dam slopes (in Russian), *Izv. In-ta Gidrol. i Gidrotekhn. Akad. Nauk USSR* **14**, 21, 76-88, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5986.

Author studies a dam having a wide crest of the order of 3 or 4 times the height of the dam, when the influence of the finite nature of the top width can be disregarded. He aims at the evaluation of the influence of the filtration pressure and the heterogeneity of the friable medium on the shape of the slope, calculated by the method of boundary equilibrium evolved by V. V. Sokolovskii ["Statics of a friable medium," Izd-vo Akad. Nauk SSSR, 1942]. To begin with, the influence of the filtration pressure is examined; when doing this the filtration forces are included with the spatial forces acting on the slope. The filtration velocity was determined on the EGDA apparatus. Calculations showed that the filtration forces influence the shape of the slope to a substantial extent; in an example cited by the author, the inclination of the slope at its foot when filtration was operating was twice as small as in the case of a dry slope. Further on, the author shows by means of examples that no less significance is possessed by the values of the alterations with depth of the volume/weight of the soil, the internal friction and cohesion. Everywhere in the calculations of the equation for particular derivatives these were replaced by calculations for the equations in end differences. Author holds that, with the indicated increased accuracy in defining the soil characteristics and with the accepted means for taking into account the forces of filtration, the Sokolovskii method "can be recommended for the calculations of the stability of the slopes of earthen dams with high supporting capacity."

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1873. Lapshin, S. G., The stresses in dams due to loads uniformly distributed along a line parallel to the crest (in Russian), *Trudi Leningr. In-ta Inzh. Vod. Transp.* no. 23, 85-90, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7004.

The method of complex variables is applied to the solution of the problem of the stress condition in an elastic wedge of infinite extent loaded by a concentrated force applied at a certain distance from the apex. A solution is developed for the case of an infinite wedge arbitrarily loaded at the apex, already given by V. M. Abramov [Trans. Conference on Optical Methods of Stress Analysis, 1937, 131-142] and P. F. Pavlovich ["Theory of Elasticity," Moscow-Leningrad, Oborongiz, 1939, 536-539].

The case is examined of a wedge with edges corresponding to the equation $\phi = \pm \phi_0$, one edge of which is loaded over the distance $R = 0$ to $R = l$ with a normal load distributed according to an exponential law $p_1(R) = p \left(\frac{R}{l}\right)^n$, where p = greatest load intensity (for $R = l$). The case of a concentrated force applied at a distance l from the apex is obtained by a transition at the limit for $n \to \infty$ and $p \to \infty$.

For the specified conditions on the contour, a general expression is derived for the stress function, after which two particular cases are analyzed: (1) A semi-plane $\phi_0 = \frac{1}{4}\pi$; (2) a rectangular wedge $\phi_0 = \frac{1}{4}\pi$. For the first case, an expression is derived for the sum of the normal stresses, and it is demonstrated that after certain transformations this can be reduced to the known form of relationship for a semiplane: $\sigma_r + \sigma_\phi = -(2P \cos \phi/\pi r)$, which leads author to conclude that the general expression thus obtained for the component expressions is completely authentic.

In the second case, the stresses σ_r on the edges of the rectangular wedge are calculated. Correlation of the numerical results of the analytical solution with the results of an experimental investigation conducted by the present abstractor [*Prikl. Mat. Mekh.* **3**, no. 4, 1939] shows a fairly close agreement, with the exception of the region in the neighborhood of the concentrated force and the region in the direct vicinity of the apex. In particular, in the analytical solution there is no point on the loaded edge ($\sigma_r = 0$) which is clearly defined in the experimental isoclinic field. On the free edge, according to the analytical solution, in immediate proximity to the apex, the stress σ_r changes sign from negative to positive, which was not apparent in the experimental solution. The latter may probably be explained by the fact that the stress value at the apex is very small, and hence in the experimental investigation the real stress field could be distorted here by a system of initial contour stresses.

N. M. Figurnov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1874. Tchaussov, N., The determination of the temperature distortion of the roadway slab on the crest of a dam (in Russian), "Researches on problems of structural engineering and the theory of plasticity," Moscow, 1956, 279-327; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7047.

The temperature deformations are determined for a rectangular prismatic beam with a nonuniform temperature distribution over the cross section, corresponding to harmonic fluctuations of the external air temperature.

The first problem solved is of the temperature distribution in the cross section of a rectangular beam for two forms of boundary condition, applying the theory of functions of a complex variable. This problem has, however, already been solved in a more general form by Fourier analysis.

It is shown that the variation in mean temperature $t_m = \int_0^1 \int_0^1 t(x, y, \theta)\, dx dy$ (x, y, are nondimensional coordinates,

θ time) develops according to a harmonic law, as in the surrounding medium, but with different phase shift and amplitude.

Applying the expression for the mean temperature, the axial deformation of the beam can be determined.

The solutions obtained are generalized for the case when the air temperature is a given inharmonic function satisfying the Dirichlet conditions for a particular time interval.

A number of numerical examples of calculation of the thermal deformation of a slab are presented.

S. V. Aleksandrovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1875. Safaryan, M. K., and Tchichko, G. M., A more accurate method of calculating waterdrop tanks (in Russian), *Neft. Kh-vo.* no. 4, 78–83, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7021.

1876. Sarkizov, G. M., and Chernysheva, B. V., The problem of the actual tensile forces acting on casing rigs at the release of the ram (in Russian), *Trudi Azerb. N.-i. In-ta po Dobyche Nefti* no. 2, 92–100, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3691.

1877. Gardner, R. M., TVA experiences, welded versus riveted spiral cases, *Trans. ASME* **80,** 5, 1147–1152, July 1958.

1878. Belyashevskii, N. N., Method of investigating the "under" water of water-shedding installations (in Russian), *Gidrotekhn. Str-vo* no. 3, 40–43, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5559.

1879. Vassiliev, A. L., An experimental investigation of the work of a horizontally-corrugated bulkhead under transverse load (in Russian), Thesis, Leningr. Inst. of Naval Architect., Leningrad, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7226.

Machine Elements and Machine Design

(See also Revs. 1688, 1739, 1811)

1880. Graziano, D. J., For streamlining and weight-saving, tap the reserve strength in metal parts, *Prod. Engng.* **29,** 40, 44–47, Sept. 1958.

1881. Spotts, M. F., An application of statistics to the dimensioning of machine parts, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-44, 6 pp.

An outstanding industrial achievement during recent years has been the development of quality control and acceptance sampling methods for the purpose of maintaining the high standards of manufactured products. It is equally important to make use of statistics in the engineering office in connection with the dimensioning of machine parts. This paper concerns the dimensioning of assemblies, and demonstrates how it is possible to maintain tolerances for proper engineering functioning, and at the same time widen the tolerances so far as production is concerned.

From author's summary

1882. Sando, R. M., and England, F. E., New shock absorber, *Prod. Engng.* **29,** 19, 86–88, May 1958.

High loads can not bulge the rubber spring in this new shock absorber. Both the load-absorbing core and its restraining girdle are silicone rubber. They give smooth spring rate plus high energy-absorption ability. Authors provide procedure for determining correct size and configuration.

From authors' summary

1883. Janiq, Z. J., Friction-clutch transmissions. Vol. II. How to analyze a clutch system, *Mach. Design* **30,** 24, 107–114, Nov. 1958.

1884. Spector, L. F., Design guide—flexible couplings, *Mach. Design* **30,** 22, 101–128, Oct. 1958.

1885. Engel, E., The torsional tendency and torsional stiffness of cables (in German), *Ost. Ing. Z.* **1,** 1, 33–39, Jan. 1958.

Mathematical treatment of torsional phenomena in cables used for cranes and rope-railways. Various types are analyzed with respect to the way the cable is made of the composing wires. Making several simplifying suppositions author derives formulas for a first-order theory, giving a linear relation between the torsional moment and the tension. A numerical example is added.

O. Bottema, Holland

1886. Wolford, J. C., and Hall, A. S., Jr., Second acceleration analyses of plane mechanisms, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-52, 20 pp.

Paper deals with analysis of second acceleration, in the sense of third time derivative of displacement or rotation, without discussing importance or otherwise of these quantities. Authors derive exact expressions for three relative second accelerations: (1) for a point P on a rigid link relative to another point O on the same link $= \overline{3OP}\,\alpha w \leftrightarrow \overline{OP}\,\alpha^{(2)} \leftrightarrow \overline{OP}w^3$; (2) for a point P_3 or a moving link, 3, relative to a coincident point P_2 on another link, 2, $= a^{(\omega)} \leftrightarrow u_2^2 v \leftrightarrow 3w_2 a \leftrightarrow 3\alpha_2 v$; and (3) for the special case of (2) when the points have zero relative velocity. In these expressions w, α, $\alpha^{(\omega)}$ are the angular velocity, acceleration and second acceleration of the link, a, $a^{(\omega)}$ are the acceleration and second acceleration which P_3 would have if link 2 were stationary and P_3 moved along its trace in link 2 at the actual relative velocity, V.

Examples are given. E. M'Ewen, England

1887. Artobolevskii, I. I., Two new precise guiding mechanisms (in Russian), *Dokaldi Akad. Nauk SSSR (N.S.)* **110,** 3, 341–344, Sept. 1956.

A study is made of some special types of five-bar linkages. The first has two fixed points around which the bars rotate. Main property of suggested construction is that on rotating one bar around its fixed endpoint the connecting point of two bars describes a perfect circle, the angular velocity of the bar and the (imaginary) radius of the special point being the same. The (materially nonpresent) center-point of the second movement does not coincide with that of the rotating bar and the distance between these points as well as the length of the radius of the resulting circular movement depends on the dimensions of the mechanism, so that these parameters can be adapted to a specific purpose. The lines connecting the two center-points and the fixed points are perpendicular.

The second mechanism is a variation of the first. The fixed parts are now a point and, at a certain distance, a straight bar along which a slider can move. The movement of the slider corresponds to that of a connecting point of two bars, this movement being perfectly rectilinear and proportional to the displacement of the slider. The angle between the two movements and the displacement ratio depends on the dimensions of the mechanism.

Both mechanisms might be useful for designers of special mechanisms and instruments. R. G. Boiten, Holland

1888. Freudenstein, F., Four-bar function generators, *Mach. Design* **30,** 24, 119–123, Nov. 1958.

1889. Lazarenko, V. M., and Freydmann, N. E., An appliance for measuring the frictional force between a traveller and a ring (in Russian), *Trudi Leningr. Tekst. In-ta* no. 5, 95–99, 1954; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6381.

Authors describe the construction of an instrument which measures the frictional force between the traveller and the ring of a ring spinning machine or doubling frame. The instrument was developed by the Leningrad Textile Institute and is based on the principle of transforming the fluctuations of the frictional force into proportional fluctuations of current recorded on a photographic film. A method is described for calibrating the instrument to determine the absolute value of the frictional force. Some examples are given of recorded curves of the changing friction of the traveller, and the necessary modifications to the machine for the case of large-diameter rings are discussed. The instrument is quite sensitive, being able to detect variations in the frictional force of the order of 0.25 g. In conclusion, data on the working of the traveller, based on the recorded changes in the frictional force exerted by it, are discussed.

G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1890. Groddeck, K.-H., Problems concerning labyrinth high pressure stuffing boxes (in German), *Forsch. Geb. Ing.-Wes.* **23**, 5, 183–195, 1957.

Paper is an abstract of a thesis of the same title written by the author in 1956 at Technische Hochschule, Hannover.

Based on an analysis of flow in a single chamber between the corrugations of a labyrinth-type packing, author derives a method of calculating the leakage losses as a function of the number of corrugations. Comparison is made between axial labyrinth-type packing, mounted on a smooth shaft, and a radial packing, proposed by G. Köhler. In the latter, the corrugations are made in both the stationary and the rotating member, the individual teeth of one member overlapping those of the other, just resulting in an almost 180° stream turning angle. The analysis is supported by some experimental work which shows Köhler's design to be superior to the conventional packing.

Author further evaluates that there is no effect of rotation on the leakage in case of laminar flow and only small reduction in leakage can be expected in turbulent flow. In some condensing steam turbines considerable reduction in leakage can be achieved by bleeding off part of the flow through the labyrinth into stages of lower pressures. The bleed-off line is connected to the labyrinth in the region where the steam is expanded to such a degree that it fills completely the volume between the teeth of the labyrinth.

Four references are quoted; however, author seems to be unaware of any of the classical publications in English language, like those by A. Egli [*Trans. ASME* **57**, 1935], W. J. Kearton and T. H. Kech [*Proc. Instn. Mech. Engrs.* **166A**, 1952] or W. J. Kearton [*Proc. Instn. Mech. Engrs.* **169**, 1955] which already covered the subject very thoroughly.

K. Pilarczyk, USA

1891. Brown, W. B., Hinges for plastic containers, *Prod Engng.* (Design Digest Issue) **28**, 15, G12–G13, Oct. 1957.

1892. Scalzo, Augustine J., How to use influence factors to calculate shaft misalignment moments, *Mach. Design* **30**, 23, 157–160, Nov. 1958.

Fastening and Joining Methods

1893. Nearn, W. T., and Clarke, J. T., Dowel joint strength, *Forest Prod. J.* **8**, 11, 326–329, Nov. 1958.

The effect is demonstrated of dowel type, size of predrilled hole, and adhesive on the joint strength. Compressed dowels produce stronger joints than dowels with helical grooves, with the latter dowels being more effective than plain dowels. The predrilled hole should be slightly larger than the dowel pin. Polyvinyl resin and hot animal glues proved to be superior to other glues tested.

E. G. Stern, USA

1894. Kobatake, Y., and Inoue, Y., Mechanics of adhesive joints. I. Residual stresses, *Appl. Sci. Res. (A)* **7**, 1, 53–64, 1958.

Authors try to find the residual stresses occuring in the adhesive layer due to the difference of thermal strain of adhesive and adherent when the temperature decreases, e.g. during glueing operations. The following problem is solved analytically and photoelastically: A rectangular plate at temperature T has its two parallel opposite edges cemented to two rigid planes. Problem is to find the stresses produced in the plate by a decrease of temperature. For the analytical solution hyperbolic functions are introduced into the biharmonic equation for plane stress. Good agreement is observed between theoretical analysis and photoelastic experiment.

A. Phillips, USA

1895. Kobatake, Y., and Inoue, Y., Mechanics of adhesive joints. II. Stress distribution in adhesive layer under tensile loading, *Appl. Sci. Res. (A)* **7**, 2/3, 100–108, 1958.

Authors consider the problem of a rectangular plate having its two parallel opposite edges cemented to two rigid planes and loaded by an external tensile force which acts perpendicularly to the cemented plane. The stress distribution is determined analytically and photoelastically. Good agreement is observed between the two methods. Conclusions are drawn concerning the application of this analysis to the mechanics of adhesive joints.

A. Phillips, USA

1896. Bikerman, J. J., Theory of peeling through a Hookean solid, *J. Appl. Phys.* **28**, 12, 1484–1485, Dec. 1957.

Author studies the following problem. Assume a long, flat, elastic ribbon, bonded to a rigid substrate by means of a thin, uniform, linearly-elastic adhesive layer. One end is loaded by means of a constant force (dead weight). The system is reduced to the case of a beam on an elastic foundation, and the dependence of deformation on system parameters is easily deduced. This configuration constitutes one form of "peel test," and the results can to some extent be correlated with such tests, although author understands that few practical adhesives are linearly elastic up to the point of rupture. The principal point of the study is that the required peeling force and the "energy of stripping" are functions of bulk mechanical properties of the system and its geometry, including (in this case) the adhesive tensile strength. Author concludes that peeling force and stripping energy give little basic information on the fundamentals of adhesion at the molecular level.

J. L. Lubkin, USA

1897. Sherrer, R. E., Stresses in a lap joint with elastic adhesive, U. S. Dept. Agric. Forest Service no. 1864, 44 pp., Sept. 1957.

Author attempts to solve the following problem: two isotropic, elastic, rectangular sheets of uniform thickness and equal length are bonded together in a lap joint by means of an elastic, isotropic adhesive layer, also of uniform thickness. The joint is acted upon by a tensile force applied to each adherend sheet at its free end. Stresses and displacements in the adhesive are sought, treating the sheets as beams in simple bending and the adhesive with plain strain theory (for consistency, either the sheets should be viewed as plates in cylindrical bending or the adhesive should be treated with plane stress theory). Boundary conditions are derived using the well-known analysis of Goland and Reissner as a point of departure [*J. Appl. Mech.* pp. A-17 to A-27, 1944]. The free boundaries of the adhesive are assumed to be straight and stress-free, but only insofar as the resultant transactions are concerned. (Hence we can expect that the calculated stresses are not in general correct near these free edges. Reviewer feels that this is unfortunate, because these regions are the ones of highest stress and thus of principal interest.)

Author then states a solution in the form of infinite series, and by application of the boundary conditions formulates matrices for the constants of integration. These are to be solved using a finite number of terms of the series in question, and boundary condition values taken from Table (1) of Goland and Reissner (op. cit.). This also is unfortunate (if the author performed his calculations as stated) because Table 1 of that reference has one column which is incorrect [see corrections on p. 1219 of reviewer's paper, *Trans. ASME* Aug. 1956, pp. 1213–1221]. In carrying out the computations, it is found that the matrices also contain two rows involving divergent series. This is because the adhesive shear stress is discontinuous on the boundary of the adhesive, where the free edge joins the adherend sheet. Author takes the position that the corresponding equations describe physical conditions of the problem, and hence must sum to a finite value. (Reviewer, on the other hand, feels that the problem needs fundamental reformulation to avoid these difficulties, and that no amount of forcing is going to circumvent them otherwise—admittedly, the correct formulation is not easy to arrive at).

Author then applies Euler's method to sum the divergent series. This generates further problems because of author's desire to be reasonably consistent in applying the transformation. He finally determines *by numerical trial* which combination of equations should be summed and which should not. Author finds that some of the infinite series involved can be made to converge satisfactorily, some converge too slowly, and some diverge. Various curves are presented, based upon the series which do converge.

In view of the many difficulties mentioned above, reviewer has serious doubts about the usefulness of the results to the student of adhesive joints. Conceivably, some of the results are quite insensitive to the paper's hypothesis and procedures, notably the "tearing stress" component σ_y, but just how to establish which results are valid and which are not is a problem in itself.

J. L. Lubkin, USA

Rheology

(See also Rev. 1901)

1898. Srivastava, A. C., The flow of a non-Newtonian liquid near a stagnation point (in English), *ZAMP* **9,** 1, 80–84, Jan. 1958.

Author treats a problem encountered in processing of non-Newtonian liquids. A solution similar to the known form solving for stagnation flow of a Newtonian liquid by use of the Karman-Pohlhausen-method yields the integration of the equations of motion. The relation of the stress matrix and the rate-of-strain matrix is used, as stated by I. Braun and M. Reiner [*Quart. J. Math.* **5,** p. 43, 1952].

Analysis shows that for flow of such liquids the physical constants, namely the coefficient of viscosity and of cross viscosity, can be combined to one characteristic parameter K. The results are presented as functions of this parameter K and also shown graphically.

In the equation before relation (6) a printing error should be corrected by changing the signs at the left side of this relation.

A. Slibar, Germany

1899. Mihailov, N. V., and Likhtgeim, A. M., Investigation of full rheological curves and formulas for the calculation of the effective viscosity of constituted liquids with a molecular-kinetic interpretation of the constituents entering into them (in Russian), *Kolloid. Zh.* **17,** 5, 364–378, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8012.

A schematic representation is given of the mechanism of flow of constituted liquids, explaining the gradualness of the destruction of the structure and its thixotropic reducibility. The flow of the constituted liquids is investigated as the sum of two simultaneously carried out processes: the destruction of the bonds of the spatial network as the result of the action of shear stresses and the reestablishment of these bonds in consequence of Brownian motion. A two-term formula is proposed for the calculation of the effective viscosity in relation to the shear stress. On the basis of the proposed formula and Frenkel's molecular kinetic theory an approximate formula is deduced for the determination of the viscosity of constituted liquids, which describes satisfactorily the course taken by the rheological curve.

R. V. Torner

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1900. Claxton, W. E., Stress-strain equation for rubber in tension, *J. Appl. Phys.* **29,** 10, 1398–1406, Oct. 1958.

Paper deals with the finite deformation of rubber by employing the concepts of nominal stress and nominal strain which are well known to have physical significance only in the case of small deformation. A stress-strain relation with variable coefficients was thus suggested. The effects of deformation and curing process on the coefficients were investigated experimentally and some interpretation is given to the observed results.

L. W. Hu, USA

1901. Jung, H., A contribution to the theory of rheologic materials (in German), *Kolloid Z.* **153,** 1, 1–5, July 1957.

Starting from the energy function first introduced by Hill, the stress-strain laws for various types of viscoelastic and plastic materials are derived.

From author's summary by B. A. Boley, USA

Hydraulics

(See also Revs. 1979, 1980, 1981, 1984, 2004, 2005, 2018, 2134, 2135, 2165)

1902. Krutzsch, J., A new method for the measurement of the density of liquids (in German), *Chimia* **12,** 11, 324–325, Nov. 1958.

1903. Haberman, W. L., and Sayre, R. M., Motion of rigid and fluid spheres in stationary and moving liquids inside cylindrical tubes, *David W. Taylor Mod. Basin Rep.* 1143, v + 67 pp., Oct. 1958.

For a preliminary report see AMR **11** (1958), Rev. 4597.

This is the complete paper, containing also the important problem of the drag on the sphere in a Poiseulle flow. Paper contains "exact solutions" for the case when the Reynolds number is so small that, in the hydrodynamic differential equations for slow motion, Stokes' approximation is adequate. The results, given graphically, agree well with experiments by the authors and others.

Authors have also given an "approximate solution." In this the formulas for the drag on the sphere are given in the form of quotients, where the denominators and numerators run in increasing powers of R/b, R being the radius of the sphere and b of the cylinder. Authors seem not to have observed that this formula has an important superiority to their "exact" solution, namely that the first correction for the inertia of the fluid can easily be taken from earlier calculations [*Arkiv Mat. Astr. Fysik* **27,** 1923]. For that reason the "approximate" formulas should be worked out very carefully. Reviewer had the opportunity to check the correctness of the approximate formulas. Torsten Bohlin, engineer from the Royal Institute of Technology in Stockholm, has solved the same problem for a rigid sphere and pushed the development of the series in the denominator to the tenth power of R/b, but the paper is not published. There are differences in the last decimals and in the coefficients for the last, i.e., the sixth, power. These differences are small but perhaps not quite insignificant. At the mo-

ment, I cannot say who is right. Be that as it may, authors have done an excellent piece of work.

O. H. Faxen, Sweden

1904. Petukhov, B. S., and Muchnik, G. F., On the problem of the hydraulic resistance in turbulent nonisothermal flow of liquids in tubes, *Soviet Phys.-Tech. Phys.* **2,** 5, 996–1000, Feb. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 1095–1099, May 1957, by Amer. Inst. Phys., N. Y.)

Paper reviews the results of systematic experiments on the hydraulic resistance of round tubes conducted in Theoretical Foundations Department, Moscow Power Institute. Tube length-diameter ratios 88–100 are used to insure fully developed turbulent flow. Both water and two types of oil are used, all progressively heated and cooled.

Empirical relation is developed for hydraulic resistance coefficient as function of Reynolds number and viscosity ratios. Good agreement is obtained between experimental points and empirical formula. F. L. Wattendorf, USA

1905. Yablonsky, V. S., Hydraulic problems of main and intraplant pipelines (in Russian), Petroleum plants and petroleum pipelines, Moscow, Gostoptekhizdat, 1956, 29–37; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6645.

Successes are reported in the solution of problems of hydraulic engineering associated with the pumping of heated high viscosity petroleum products along main pipelines: (1) determination of the loss of head; (2) determination of the economically optimum temperature corresponding to minimum energy loss in heating and pumping; (3) determination of optimum working conditions for petroleum pipelines in relation to annual, seasonal and occasional fluctuations of the ambient temperature and temperature of the working product. It is pointed out that, for the correct determination of the coefficient of hydraulic resistance of pipes, there are a sufficient number of formulas available which satisfy modern conceptions on turbulence, but difficulties arise in this regard, such as the selection of coefficients of tube roughness, depending on the tube material, method of manufacture, service life, etc.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1906. Etcheyistov, Yu. A., and Klabukov, V. M., Equipment and methods for investigating unsteady states in pressure pipelines at the Mingechaur hydroelectric power station (in Russian), *Trudi Mosk. Inzh.-stroit. In-ta* no. 16, 111–118, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6653.

A brief description is given of the structures of the Mingechaur power station. Authors describe the apparatus used to check the correctness of the selected size of diaphragm for the balancing reservoir and to determine the magnitude and character of the dynamic pressures arising in the turbine feed pipe during unsteady running.

The following measurements are made in the investigation: pressure variation in the turbine pipe, opening of the turbine guide ring, speed of rotation of the power unit, and the time. The measured values are recorded on an oscillogram.

The article also describes the arrangement of the observation (measuring) stations and the sequence of the experimental measurements. Ya. N. Flekser

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1907. Folkel, K., Computation of backwater curves by the integration method (in German), *Bautechnik* **35,** 4, 121–125, Apr. 1958.

Paper presents previous work by Bakhmeteff on nonuniform channel flow ["Hydraulics of open channels," McGraw-Hill, 1932]. Author's contribution consists of presenting results in form of nomographs. W. L. Haberman, USA

1908. Potapov, I. V., Investigation of hydraulic impact in a circular pipe system with branching pipes (in Russian), *Trudi Novocherkas. Politekhn. In-ta* nos. 33/47, 115–125, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7867.

1909. Piquemal, J., Use of electric analogy for determination of water hammer overpressures (in French), *C. R. Acad. Sci., Paris* **245,** 14, 1117–1119, Sept. 1957.

Author has devised electrical analogy for the water-hammer problem. Constant level reservoir feeding pressure conduit is represented by constant voltage source and delay line, in which the velocity of electric wave propagation corresponds to that of pressure waves in the conduit.

Key to the system is a pentode, with potentiometer connected between the screen grid and the constant voltage source. By adjustment of potentiometer, pentode can be made to function fully as pentode, fully as triode, or as combination, depending on characteristics of hydraulic problem. Operation of valve—closing or opening, full or partial, instantaneous or slow—is given by adjusting voltage to control grid of pentode. Representative examples for sudden opening and closing of gates yield analog results agreeing within 0.5% of those obtained by calculations based on Bergeron's method.

The pentode may also be moved to a point in the delay line to represent a break in the conduit. Analog results again compare favorably with calculated data. A. C. Ingersoll, USA

1910. Liubimtsev, Ya. K., Stability of stationary conditions of hydroelectric power plants having differential surge tanks (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 48–56, Jan. 1957.

Incompressible Flow

(See also Revs. 1958, 1975, 2070, 2087, 2097, 2138, 2166)

Book—1911. Kaufmann, W., Technical hydro- and aeromechanics [Technische Hydro- und Aeromachanik], 2nd ed., Berlin, Springer-Verlag, 1958, viii + 386 pp. DM 37.50.

This textbook is a slightly expanded version of the first edition [AMR **8** (1955), Rev. 1034]. Additions are new sections intended to make the coverage of the field more complete. For example, the Navier-Stokes equations are presented in cylindrical coordinates, the energy equations for boundary-layer flow are developed, the drag of rotating cylinders and plates is analyzed, the boundary-layer equations for compressible flow are developed and significant experimental studies are discussed.

Reviewer believes that additions are valuable, considering purpose of book. All of them cover topics in which work has recently been carried forward and which are of current practical interest.

Considering book as a whole reviewer finds it to be much different from any available in the English language. It is much more advanced than standard engineering texts used in North America in that besides the elementary, one-dimensional type of analysis the complete two- and three-dimensional flow equations are introduced and analyzed. The format is also different in that the one-dimensional equations are introduced first including effects of friction, gravity and surface tension. The more complex flows are subsequently dealt with where geometry is of primary importance. Teachers, graduate students, and research workers in any field of fluid mechanics will find this a valuable reference book.

W. D. Baines, Canada

1912. Zabriskie, W., and Sternlicht, B., Labyrinth-seal leakage analysis, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-118, 5 pp.

The leakage flow through labyrinth seals in turbomachinery has been the subject of increasing concern as refinements and advances in design are made. Accurate knowledge of seal leakage is necessary in at least three areas of design: (a) Estimating the effect of seal leakage on performance; (b) regulating the leakage flow required for cooling purposes; (c) determining the thrust-bearing load which is a function of the pressure drop through the seal. This paper is concerned primarily with the fluid-flow aspect of gas leakage through labyrinth seals of the types commonly used in gas and steam turbines. This includes staggered and unstaggered seals of the axial type, which are most commonly used in turbomachinery. The attention to fluid-flow considerations does not imply that material compatibility and operating problems of expansion, deformation, and rub-in are unimportant. In fact, these mechanical considerations may overrule the fluid-flow considerations. For the foregoing reasons, it is desirable to be able to predict seal leakage flows. From authors' summary

1913. Kline, S. J., Abbott, D. E., and Fox, R. W., Optimum design of straight-walled diffusers, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-137, 9 pp.

The four common optimum problems in diffuser design are defined. These optima are located in relation to the over-all flow regimes in terms of geometrical parameters for straight-walled units. Using an empirically derived transformation of variables between the conical and two-dimensional geometries, all available data for optimum recovery at constant ratio of wall length to throat width are correlated by a single straight line. This line lies slightly above and parallel to the line of onset of large transitory stall on the chart of over-all flow regimes. The correlated results are based on a literature survey. The range of conditions for each investigation is tabulated for convenient future reference.

From authors' summary

1914. Bressler, R., Experimental determination of pressure loss for cross-flow through tube banks (in German), *Kältetechnik* **10,** 11, 365–368, Nov. 1958.

Friction factors as a function of the Reynolds number have been determined for staggered and in-line tube banks consisting of one to ten tube rows. For each row the pressure distribution around a single tube has been measured.

From author's summary

1915. Dou-Gozhen', Turbulent motion of a liquid conditioned by the rotation of a cylinder in a stationary concentric cylinder of large diameter (in Russian), *Sb. Nauch. Rabot. Stud. Nauch. O-vo Leningrad In-ta Inzh. Vod. Transp.* no. 1, 5–12, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8028.

Formulas are deduced for the distribution of velocity between two infinitely long rotating cylinders when the turbulent flow of the liquid is in a steady state. The case of the rotation of the inside cylinder is investigated. The principle of the distribution of velocity is derived from the conditions of constancy of the moment of tangential forces relative to the cylinder axis, acting on the cylindrical surface of radius

$$L_{mp} = A\tau \frac{d\omega}{dr} 2\pi r^3, \quad \omega = \frac{v_\theta}{r}$$

where L_{mp} is the moment of tangential forces, v_θ the tangential velocity, A the coefficient of turbulent viscosity. The boundary conditions on the walls of the cylinders are taken in conformity with V. M. Makkeveev's formula in the form of $v_s + l \frac{\partial v_s}{\partial n} = 0$, where v_s is the velocity at the wall, l the parameter, characteristic of the roughness of the surfaces of the solid walls, n the external norm to the wall. The formulas obtained for the distribution of the velocity make it possible to determine the value of the roughness parameter if measurements are carried out for ω and ω_0 (ω_0 being the angular velocity of the cylinder's rotation).

V. I. Yagodkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1916. Gol'din, E. M., Motion of liquids in reservoirs (in Russian), *Sb. Trudi Obshchetekhm. Kafedr. Leningrad Tekhnol. In-ta. Kholodiln'. Prom-sti* **12,** 72–90, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7822.

A study is carried out of plane settled flows of an ideal incompressible liquid in rectangular regions. Use is made of the known conforming reflections with the aid of Jacobi's elliptical functions. On the basis of the investigations carried out a few ideas are expressed regarding the character of possible real flows in rectangular reservoirs. V. P. Pilatovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1917. Eckert, E. R. G., and Irvine, T. F., Jr., Rearrangement of the temperature field in a flow around a bend, ASME Gas Turbine Power Conf., Washington, D. C., Mar. 1958. Pap. 58-GTP-2, 8 pp.

The effect of secondary flow on the temperature and velocity fields in a 90° bend, having accelerating flow, has been investigated. Good agreement is found by a simple calculation, which is also presented. The importance of a rearrangement of the temperature field is discussed, with special reference to gas turbines.

Secondary flows are usually met with whenever there is a turning of the main flow. Reviewer met with such a flow in an investigation of the mixing of coaxial jets in a pipe [AMR **8** (1955), Rev. 2150]. These flows cause part of the losses and have to be closely considered in the design of various fluid-flow machinery. Hence reviewer feels that this paper is interesting and useful.

Y. V. G. Acharya, India

1918. Gol'din, E. M., Movement of viscous liquid in the interdisk spaces of separators (in Russian), *Inzh. Sb. In-ta Mekhaniki, Akad. Nauk SSSR* **15,** 137–146, 1953; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 622.

1919. Lemaire, L. H., and Grassmann, P., Dynamics of the flow of a two-phase fluid (in French), *C. R. Acad. Sci., Paris* **246,** 9, 1378–1379, Mar. 1958.

1920. Keller, J. B., and Weitz, M. L., A theory of thin jets (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; **2,** 316–323.

Irrotational flow under the influence of gravity is studied for a liquid jet whose characteristic vertical thickness b is small compared with the horizontal distance a traversed by the flow. By extension of method developed for shallow water theory [AMR **2** (1949), Rev. 1029] authors indicate how solutions may be obtained as series in powers of (b/a). Method is demonstrated to zero-order approximation for unsteady jets, to first-order approximation for unsteady jets, and, with a slight modification of the method, to zero-order approximation (with pressure variation to first order) for unsteady flow over a rigid surface, e.g. a spillway. Misprints make the paper difficult reading.

G. D. S. MacLellan, England

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 1913, 1939, 1943, 1960, 1961, 1965, 1968, 1969, 1971, 1988, 2011, 2012, 2043, 2045, 2064)

Book—1921. von Mises, R., Mathematical theory of compressible fluid flow (Applied Mathematics and Mechanics, Vol. III) New York, Academic Press, 1958, xiii + 514 pp. $15.

Reviewer believes he can best characterize this book by giving a subtitle like "The fundamentals of the compressible fluid flow, its physical conception and its theoretical description." In a clear, complete and simple manner book represents a very good basic treatment of compressible flow theory and the roots for its application. As a consequence of von Mises' idea to embody a central branch of fluid mechanics no extension for technical use is given, but will also not be missed by the reader.

After a very clear derivation of basic equations, chapter I treats the influence of viscosity and heat conduction, sound velocity and wave equation and the subsonic and supersonic steady motion. General theorems: the vortex theory, irrotational motion, steady flow relations and the theory of characteristics follow in chapter II. Von Mises discusses the one-dimensional flow in chapter III: steady flow with viscosity and heat conduction, nonsteady flow of an ideal fluid, simple waves and shock phenomena with examples. After von Mises died, H. Geisinger and G. S. S. Ludford continued to write the last two chapters using the author's papers and lecture notes as a guide. The plane steady flow is given in chapter IV with the hodograph method, definition, properties and examples of simple waves, singularities and limit lines of the hodograph transformation and Chaplygin's hodograph method. Chapter V introduces the integral theory (development of Chaplygin's method and Bergmann's method), the shock theory with simple examples, nonisentropic flow and two-dimensional transonic flow.

Very useful "Notes and Addenda" give a careful choice of added remarks and references, and help to increase knowledge or to find further applications. F. W. Keune, Germany

1922. Payne, P. R., Jet drag of wings with jet flaps—An examination of Stratford's theory of jet drag, *Aircr. Engng.* **30,** 349, 73–81, Mar. 1958.

It is shown that Stratford's equation for jet density after mixing [AMR **10** (1957), Rev. 1567] is accurate only for the case where the jet is "cold." A correction factor K is therefore added which varies chiefly with jet temperature. Applying the density correction on the momentum flux behind an airfoil with jet flap a reasonable agreement with Stratford's approximation is found in some areas, but differences of magnitude and sign in others. It is suggested that, contrary to Stratford's hypothesis, momentum flux has little relationship to the force acting on the airfoil, because there is no mechanism whereby the momentum flux may be converted into a thrust force on the wing. By using a potential flow model it is shown that the most important factor is the slope of the airfoil surface near the trailing edge and that jet drag is zero if this slope is zero. The same result is expected to apply when the jet emerges elsewhere on the airfoil. If the slope is "negative," or the jet emerges forward of the maximum thickness point, a thrust force in excess of the momentum value is theoretically possible. In practice this theoretical gain is more than offset by an increase in skin friction drag, as is shown in the appendix.

W. Wuest, Germany

Book—1923. Guderley, K. C., Theory of transonic flow [Theorie Schalnaher Stromungen], Berlin, Springer-Verlag, 1957, xv + 376 pp.

The subject of transonic flow has been studied both experimentally and theoretically for several decades, but it is only since the end of World War II that a body of theory has emerged that is capable of yielding solutions that are physically realistic. The author of the present volume has been one of the most prominent contributors in the development of a successful theory for transonic flow, and his authoritative book forms a welcome addition to the permanent literature on gas dynamics.

This book continues the pattern established by the author in a long list of individual reports of treating relatively restricted classes of problems with a high degree of exactitude, thereby necessitating application of rather advanced mathematical techniques. These are presented in a clear and well-organized manner and should make the book of considerable interest and value to applied mathematicians as well as to aerodynamicists. Little or no attention is paid, however, to the much broader class of problems for which results can be obtained only by more approximate methods or by experiment. As a result, the engineer seeking information regarding pressing problems involving transonic flow will probably, in most cases, have to look elsewhere.

The book is divided into 11 chapters. The first two are concerned with a presentation of the fundamental ideas and relations of compressible flow theory, the simplification of the equations to the simplest form, still nonlinear, that is sufficient for the study of transonic flow past thin airfoils and slender bodies, and a brief account of the similarity rules. The third chapter presents a discussion of some simple problems, involving both steady and unsteady flows, that can be treated by the linearized theory of compressible flow. Next follows a short chapter in which some exact solutions of the nonlinear equations of the small disturbance theory of transonic flow are presented for flows in particular Laval nozzles and for external flows that involve expansion of an initially parallel sonic flow. The next two chapters provide a lucid presentation of the fundamentals of the hodograph method, and an illuminating discussion, partly qualitative in nature, of several properties of transonic flows that can be deduced by considering the hodograph diagram. There follows a valuable chapter devoted to a detailed account of the mathematical properties of several particular solutions of the Tricomi equation, to which the equation of the small disturbance theory of two-dimensional transonic flow reduces when expressed in hodograph variables. The next two chapters present an account of numerous applications in which these particular solutions are combined to solve problems of engineering significance. Most of these are concerned with either sonic or nearly sonic flow past wedge and flat-plate airfoils and are taken from the personal researches of the author and his associates.

Two remaining chapters, both relatively brief, are concerned with a number of separate subjects, including such topics as the flow in the throat of a Laval nozzle, axisymmetric flows, the asymptotic behavior of the flow at very great distances from a body, and others. The book closes with an extensive list of references that extends for more than 10 pages.

J. R. Spreiter, USA

1924. Helliwell, J. B., An application of the Weber-Orr transform to the problem of transonic flow past a finite wedge in a channel, *Proc. Camb. Phil. Soc.* **54,** 3, 391–395, July 1958.

An analysis is presented of steady two-dimensional subsonic flow of a compressible inviscid gas past a thin finite wedge in a channel with parallel walls under the assumptions that the flow breaks away from the shoulder of the wedge and that the fluid velocity along the free streamline is subsonic or sonic. The analysis is based on the equations of the small disturbance theory of transonic flow, as expressed in terms of hodograph variables, and is concerned, therefore, with the solution of Tricomi's equation subject to the appropriate boundary conditions. An expression for the solution is obtained in terms of integrals involving Bessel functions by application of the Weber-Orr transform. No numerical results are given. J. R. Spreiter, USA

1925. Fiecke, D., Comparison of the theoretical and experimental drag coefficients for sonic and supersonic conditions (in German), *Z. Flugwiss.* **6**, 2, 36–47, Feb. 1958.

Drag coefficients obtained from measurements on various shapes of wings and bodies in sonic and supersonic flow are compared with the corresponding values obtained from linearized supersonic flow theory. The general and comprehensive presentation of the various components of drag is to be considered as a first attempt to produce some basic information, from which to estimate, by comparing experiment and theory, the approximate change of drag with Mach number. From author's summary

1926. Randall, D. G., Supersonic flow past quasi-cylindrical bodies of almost circular cross-section, *Aero. Res. Counc. Lond. Rep. Mem.* 3067, 17 pp., 1958.

Author extends theory of Ward [AMR **1** (1948), Rev. 1509] on the linearized flow past a quasi-cylindrical tube moving at supersonic speeds. Using Laplace transforms author finds general expressions for flow past bodies where the boundary conditions can be satisfied on a circular cylinder whose axis is parallel to the free-stream flow. Certain functions used in finding the flows are computed and presented in tabular form.

The general theory is applied to the case of the flow along a circular cylinder surmounted by a canopy at Mach number 1.4. Theoretical value for drag agrees fairly well with experiment.

Author points out how method may be extended to solve certain wing-body interference problems. R. C. Roberts, USA

1927. Wegener, F., and Kowalke, F., The drag coefficient of wings and fuselages in connection with linear supersonic theory (in German), *Z. Flugwiss.* **6**, 2, 29–35, Feb. 1958.

Wave drag of wings and of bodies at zero lift as obtained from linearized supersonic flow theory are given. The drag component due to lift is estimated for wing alone and for wing-tail unit configurations. From authors' summary

1928. Scala, S. M., and Sutton, G. W., The two-phase hypersonic laminar boundary layer—a study of surface melting, Heat Trans. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 231–240.

A solution, valid at the stagnation point, is given for the title problem. The example calculated is that for an axisymmetric Pyrex nose cone flying at $M = 20$ and at 100,000-ft altitude. A steady state is assumed. The procedure is to solve the liquid and gas phases separately for a range of interface parameters and then match the results. The liquid phase solution was given earlier by Sutton [*J. Aero. Sci.* Jan. 1958]. The gas phase solution is given for a frozen state but with variable Prandtl and Lewis numbers.

S. H. Maslen, USA

1929. Van Dyke, M. D., The supersonic blunt-body problem—review and extension, *J. Aero/Space Sci.* **25**, 8, 485–496, Aug. 1958.

The problem of the detached shock has attained new importance with the introduction of the hypersonic nose cone problem. Present paper gives a review of existing methods to compute such flows and proposes a new method which gives accurate results in a relatively simple manner. The method starts with an assumed location of the shock and calculates the flow downstream by a marching process starting from the shock conditions. Judicial choice of the intervals of the process avoids the well-known instability of this type of procedure. Comparison with the more exact method due to Garabedian-Lieberstein shows good agreement but with considerably less labor. (Typical case required only 5 to 10 minutes with the Van Dyke procedure on the IBM 650 machine.) The Van Dyke procedure would thus be ideal to investigate electromagnetic and real gas effects which might prove of significance in the blunt-body problem. H. Yoshihara, USA

1930. Kanwal, R. P., Determination of the vorticity and the gradients of flow parameters behind a three-dimensional unsteady curved shock wave (in English), *Arch. Rational Mech. Anal.* **1**, 3, 225–232, May 1958.

Author presents generalization to arbitrary equation of state of his and other previous work on the jump conditions across curved three-dimensional unsteady shocks. Analysis is designed to display clearly that the jump in vorticity is independent of the energy and state equations. Paper concludes with a simpler derivation of Thomas' compatability conditions for jump relations.

L. Talbot, USA

1931. Kompaneets, A. S., Automodel problem of shock wave development from compression wave (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **107**, 1, 29–32, Mar. 1956.

1932. Kontorovich, V. M., Concerning the stability of shock waves, *Soviet Phys.-JETP* **6**, 6, 1179–1180 (Letters to the Editor), June 1958. (Translation of *Zh. Eksp. Teor. Fiz. Akad. Nauk SSSR* **33**, 1525–1526, Dec. 1957 by Amer. Inst. Phys., New York, N. Y.)

1933. Russell, G., Unsteady flow including shock waves around a slender two-dimensional body moving at high supersonic speeds, Cornell Univ., Grad. School of Aeronautical Engineering, [ASTIA AD 136 748], 39 pp., Sept. 1957.

Approximate solutions to problems described in title are obtained by an extension of "piston" theory, which neglects factors $1 + 0\,(1/M_\infty^2)$. Cases of a plunging flat plate, and wedges rotating with constant angular velocity, or oscillating, about a fixed point are worked out for $M_\infty = 5$. G. N. Ward, England

1934. Hammerling, P., and Kivel, B., Heat transfer to a sphere at the transition from free molecule flow, *Phys. Fluids* **1**, 4, 357–358, July–Aug. 1958.

1935. Aroesto, H., and Rudin, M., Relaxation lags in gas flow, *Jet Propulsion* **28**, 10, 690–691 (Tech. Notes), Oct. 1958.

1936. Chang, C.-C., and Hsu, C.-T., Solutions to Stoolman's external diffusion equation for instability of a normal shock inlet diffuser, *Jet Propulsion* **28**, 7, 457–460, July 1958.

Paper analyzes the behavior of a flow disturbance propagating upstream in the subsonic flow ahead of a diffuser inlet and reflecting back from the detached normal shock outside the inlet. From the one-dimensional, nonviscous steady flow model it is shown that the flow disturbance is always attenuated, so that the diffuser is intrinsically stable. Authors forecast further publication showing that instability is exhibited in a model with viscous dissipation, implying that instabilities observed in practice are due to viscous dissipation. E. W. Price, USA

1937. Carter, D. J., Jr., and Vick, A. R., Experimental investigation of axial and normal force characteristics of skewed nozzles, *NACA TN* 4336, 11 pp. + 20 figs., Sept. 1958.

An investigation of axial and normal force characteristics of skewed nozzles and ejectors with skewed shrouds, all discharging into quiescent air, has been conducted. Simple skewed nozzles of varying geometry and ejectors consisting of either an axisymmetric or skewed primary nozzle shrouded by a secondary skewed nozzle were tested with a cold jet at jet total-pressure ratios up to approximately 6.5. For ejectors, diameter ratios varied from 1.05 to 1.45 and spacing ratio from 0.5 to 2.87. Normal forces amounting to 25% of the axial thrust were produced by several skewed nozzles and certain ejector-type nozzles operating at the higher pressure ratios. From authors' summary

1938. Kennedy, E. C., Calculation of axisymmetric isentropic spike surfaces, *J. Aero/Space Sci.* **25,** 7, 463–464 (Readers' Forum), July 1958.

Boundary Layer

(See also Revs. 1928, 1952, 1955, 2055, 2092)

1939. Nielsen, J. N., Application of the generalized W-functions to problems in fluid dynamics (in English), 9th Congres Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 165–172.

The tables of W-functions, particular solutions of the linearized equations of the supersonic flow potential with axial symmetry, have been extended for axial and radial arguments up to 10 times the fuselage radius and contain now about 70,000 values. Usefulness of tables is illustrated by two examples: Graphs of pressure on fuselage indentations and of shape of boundary layer on circular cylinder impulsively moved with constant force are shown. The latter are remarkably different from Blasius profile for stationary laminar flow.

Other possible applications mentioned include unsteady two-dimensional supersonic flow; interference between fuselage and external stores, between body and oblique shock, between tip-tanks and wings, between vortex and wing panel; and minimization of wing-fuselage interference in Mach number range unaccessible to NACA area rule. G. W. Braun, USA

1940. Mitchell, A. R., and Thomson, J. Y., Finite difference methods of solution of the von Mises boundary-layer equation with special reference to conditions near a singularity (in English), *ZAMP* **9,** 1, 26–37, Jan. 1958.

The von Mises transformation brings the equations for the laminar boundary layer in the nondimensional form $z_x = uz_{\psi\psi}$, where x denotes coordinate along plate, ψ stream function, u velocity in x-direction and $z = u_1^2 - u^2$, where u_1 is the free-stream velocity outside the boundary layer, which in the present investigation is taken equal to $1 - x$. This parabolic equation is solved by a finite difference procedure. For suitable mesh lengths such procedure is stable if $z_{\psi\psi}$ is positive. Hence there exists an unstable region near the plate, since there z_x and $z_{\psi\psi}$ are negative. This instability, however, is not due to $z_{\psi\psi}$ becoming infinite at the plate, as other investigators have thought. If $u_1 = 1 + x$, $z_{\psi\psi}$ still is infinite at the plate, but near the plate it is positive and the difference procedure is stable.

In the unstable region the numerical values are obtained by introducing a power series in $\psi^{1/2}$ for u. Since the unstable region is only a thin region near the plate, the coefficients in this expansion can be obtained by aid of the solution in the stable region.

A. I. van de Vooren, Holland

1941. Ambrok, G. S., The effect of surface temperature variability on heat exchange in laminar flow in a boundary layer, *Soviet Phys.-Tech. Phys.* **2,** 4, 738–748, Apr. 1957. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 4, 812–821 by the Amer. Inst. Physics, New York, N. Y.)

Author develops a relationship giving the coefficient for forced convection heat transfer from a nonisothermal flat surface. This relationship is in the usual form of $\mathrm{Nu} = \psi\sqrt{R_e}$, where ψ is a complex function of the Prandtl modulus, and the velocity and temperature variation. Solution is illustrated with application to the case of x^m variation of velocity and x^n variation of temperature head, i.e., difference between surface temperature and undisturbed stream temperature. Cases of arbitrary variations require graphical or numerical solutions. T. J. Connolly, USA

1942. Hsu, E. Y., and Macovsky, M. S., Measurement of transition on a sphere at high Reynolds numbers, *David W. Taylor Mod. Basin Rep.* 1110, 12 pp., June 1957.

A hot-wire survey was conducted on a smooth 18-in. sphere to determine the position of boundary-layer transition from laminar to turbulent flow. Tests run both in a towing basin and in a transonic wind tunnel, at Reynolds numbers from 2.2 to 3.5×10^6 (based on diameter), indicated transition in a region 90 degrees from stagnation. This result agreed qualitatively with predictions based on neutral stability theory which indicated that transition should be expected to occur at angles greater than 84° from the stagnation point in the Reynolds number range of these tests.

From authors' summary by M. H. Bertram, USA

1943. Ryley, D. J., and Barrow, H., Discharge coefficient of an elementary steam nozzle, *Engineer, Lond.* **206,** 5353, 338–340, Aug. 1958.

The discharge coefficient of an elementary convergent-parallel nozzle passing superheated steam at low pressure was determined by the authors by comparing the condensed efflux with the theoretical flow. An attempt was made to correlate the values thus obtained with values predicted by considering the growth of a turbulent boundary layer. The agreement was good for a small fall in pressure, a condition approximating to incompressible flow, but less satisfactory for a subcritical back-pressure. Some suggestions are advanced to account for the disparity.

From authors' summary

1944. Kline, S. J., and Runstadler, P. W., Some preliminary results of visual studies of the flow model of the wall layers of the turbulent boundary layer, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-64, 5 pp.

Preliminary studies of the flow model in the wall layers of the turbulent boundary layer are presented. Results are summarized for investigations of positive pressure gradients, zero and negative pressure gradients, readjusting zones, and the later stages of transition. In all cases, the special visual methods developed for these studies show a definite three-dimensional vortex-flow model. The presently available details of this model are described, a possible interpretation of the physics of the turbulent boundary layer is given, and some of the many implications of the flow model are discussed. From authors' summary

1945. Depassel, R., Flow of air at high speeds in a tube with circular cross section (in French), *C. R. Acad. Sci., Paris* **246,** 12, 1800–1803, Mar. 1958.

Taking into account the effects of transverse curvature, author extends Gruschwitz's method [*ONERA* no. 47, 1950] for calculating turbulent boundary layer in two-dimensional flow to the case of the boundary layer along circular pipe. Y. H. Kuo, China

1946. Droblenkov, V. F., The turbulent boundary layer on a rough curvilinear surface, *NACA TM* 1440, 9 pp. + 3 figs., Sept. 1958. (Translation of **Turbulentnyi pogranichnyi sloi na sherpokhovatoi krivolineinoi poverkhnosti,** *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 1955.)

A method has been derived for the calculation of the turbulent boundary-layer skin-friction drag on a flat plate or a curvilinear surface with a pressure gradient with or without distributed roughness. The method has been checked by comparing the calculated with the measured drag of an airfoil smooth and with each of two grades of carborundum on the surface. The calculated drags compared very well with the measured drags.

From author's summary

1947. Tagori, T., Hot-wire measurements applied to the detection of the transitional flow in the boundary layer around ship models (in Japanese), *J. Soc. Nav. Arch. Japan* **103,** 1–10, July 1958.

The state of flow in the boundary layer around four ship models was observed by applying hot-wire measuring technique, and the areas of laminar, transitional and turbulent flows on ship models were determined. The effect of turbulence stimulation by a trip wire or plate studs was confirmed by this means, thereby making it clear that the area of transition was considerable at low speed in spite of the use of these devices. Further, it was found that the area of laminar or transitional flow was larger on the full model than the fine model.

From author's summary by T. Inui, Japan

1948. Hidalgo, H., On the application of Van Driest's method to a highly cooled partially dissociated turbulent boundary layer, *Jet Propulsion* **28,** 7, 487–488 (Technical Notes), July 1958.

Note shows that, if the density of a dissociating gas is inversely proportional to its enthalpy, which is approximately true in some cases, Van Driest's relations between wall shear, Mach number, temperature ratio and Reynolds number can be used; only modification required is replacement of temperature by enthalpy.

Reviewer remarks that when density-enthalpy relation is more complex, as for example when surface burns in gas stream, Van Driest's approach can still be used, though quadratures have to be evaluated anew. Labor involved is relatively small.

D. B. Spalding, England

1949. Hunratty, T. J., and Flint, D. L., Velocity profile for fully developed turbulent flow in a pipe, *AIChE J.* **4,** 2, 132–136, June 1958.

Fully developed turbulent flow in pipes is treated as a problem in molecular and turbulent eddy diffusion of momentum using the general equation for diffusion $(\partial/\partial t)\rho U = \beta \nabla^2 \rho U$ where ρU = the momentum, β = diffusivity. The momentum decrement diffusing into the flow from the wall plus the momentum arising due to the negative pressure gradient in the flow is taken as a constant (conservation of momentum). The treatment is restricted to homogenous isotropic turbulence.

Four cases are discussed:

Case I. Molecular transfer of momentum: The diffusivity is given by $\beta = \mu/\rho$ and the resulting velocity profile is shown to be parabolic and hence in agreement with the well-known solution for the Navier-Stokes equations.

Case II. Molecular transfer and turbulent transfer with no time dependency: The diffusivity is given by $\beta = \mu/\rho + \epsilon$ where ϵ is the eddy diffusivity. This solution again results in a parabolic velocity profile.

Case III. Turbulent transfer with time dependency: The diffusivity is given by $\beta = V^2 r \left[1 - \exp\left\{\frac{-(t-t')}{r}\right\}\right]$, where $r = \int_{t'}^{\infty}$, $R_{tt'}dt$ = time scale, $R_{t-t'} = \frac{\overline{v_t v_{t'}}}{v^2}$ = Lagrangian correlation factor, $R_{t-t'} = \exp\left\{\frac{-t-t'}{r^2}\right\}$, v^2 = intensity of turbulence.

The velocity profile goes to minus infinity at the pipe wall since in this area the molecular diffusion becomes dominant.

Case IV. Molecular transfer and turbulent transfer with time dependency $\beta = \mu/\rho + v^2 rc \left[1 - \exp\left\{\frac{-(t-t')}{r-c}\right\}\right]$: A different value of the time-scale factor r_c is used than in Case III since molecular transfer tends to reduce the value of r. The addition of molecular diffusion permits satisfaction of the boundary conditions at the wall.

Velocity profile plots are given for cases III and IV. Comparison is made with experimental measurements of Nikuradse. Some experimental measurements of r and $\overline{v^2}$ are given.

E. K. Parks, USA

1950. Kalikhman, L. E., Conversion of equations of a turbulent boundary layer in gas to linear ordinary differential equations and their solution in final form (in Russian), *Dokladi Akad. Nauk SSSR* **106,** 3, 401–404, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7982.

The conversion is shown of the integral correlations of impulses and energy to two linear ordinary differential equations, based on the introduction of new functions and the use of an assumption regarding the constancy of some values subject to only small variations. The integrals of these equations are essentially functions, one of which is proportional to the relation of the amount of impulse loss to the surface friction stress, while the other,—the relation of the amount of energy loss to the square of the heat emission. Friction stress, heat emission coefficient and the other characteristics of the boundary layer can be determined after the establishment of the formulas for resistance and heat emission. It was found that analogous results are obtained in the case of an axially symmetrical flow of gas.

A. A. Yarkho

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1951. Brun, E. A., Dorand, D.-F., and Plan, M., Experimental study of the mechanism of transition in the flat-plate boundary layer at supersonic speeds (in French), *C. R. Acad. Sci., Paris* **245,** 18, 1507–1510, Oct. 1957.

Velocity-profile survey was made over a flat plate at Mach 1.8 by use of a 0.2-mm tube. The boundary-layer thickness was about 0.7 mm. The zero-velocity height, as obtained by extrapolation of linear portion of the velocity profile, was found to be maximum at $x = 90$ mm before the boundary layer reattached at $x = 120$ mm and became turbulent at $x = 145$ mm. From this and the visualized observation of methyl acetate injection, authors conclude the presence of separation and backflow before transition. A similar survey was also made in the boundary layer tripped by a thin nylon thread.

The paper is too short and sketchy to convince the readers.

F. R. Hama, USA

Turbulence

(See also Revs. 1904, 2089)

1952. Dupassel, R., High speed flow of air in a cylindrical tube (in French), *C. R. Acad. Sci., Paris* **246,** 11, 1657–1659, Mar. 1958.

Author shows that in the case where velocity inside a turbulent boundary layer is given by power law with exponent $1/n$, boundary-layer thicknesses can be calculated in terms of n and Mach number of the flow.

Y. H. Kuo, China

1953. Lessen, M., On the hydrodynamic stability of curved laminar flows (in English), *ZAMM* **38,** 3/4, 95–99, Mar./Apr. 1958.

Equations describing the development of initial disturbances are derived for curvilinear flow from the Navier-Stokes equations, including the incompressible and the compressible case. In the first case disturbances may become unstable depending on the geometry of the mean flow. In the second case thermodynamic factors are also important. It is shown that then the first order effects of velocity gradient and entropy gradient are opposite if the two have the same sign. In particular the flow near a blunt body behind the shock wave in a supersonic flow is considered. Different regions are distinguished where velocity and entropy gradients may have either cumulatively destabilizing effects or opposite effects due to cooling by the body (heat sink).

J. O. Hinze, Holland

1954. Napolitano, L. G., Turbulent mixing of two streams of different gases (in Italian), *Aerotecnica* **37**, 6, 301–310, Dec. 1957.

For Prandtl and Lewis numbers equal to unity, a system of equations of state, of total enthalpy, of continuity and of motion are considered. When the flow has reached a self-preserving equilibrium condition, these systems of equations are combined into a single ordinary differential equation. In order to achieve this result, the concept of constant virtual kinematic viscosity, and a quadratic dependence of density on the velocity, were used in the equations of motion. Approximate solutions in series form are given for various undisturbed velocity and mass-per-unit-volume ratios in the two streams. Comparison is made of these solutions with exact solutions obtained from computers.

S. Eskinazi, USA

1955. Schultz-Grunow, F., On the generation of axial vortices in boundary layers (in German), *ZAMM* **38**, 3/4, 85–94, Mar./Apr. 1958.

A single obstacle or roughness element at the wall induces a circulation in the shear flow of the boundary layer because of unsymmetric flow conditions, which, owing to the finite lateral dimensions of the obstacle, gives rise to trailing axial vortices. These vortices produce in the wake of the obstacle a flow towards the wall, thus transporting fluid with a greater axial velocity from regions farther away from the wall into the wake region. This explains, for instance, Schlichting's negative wake (velocity maximum instead of velocity minimum).

Author shows that at plane walls axial vortices can only form neutral disturbances, so that for the transition into turbulence lateral vortices must be present. Such lateral vortices may be produced for instance as starting vortices in unsteady flow (Theodorsen horse-shoe vortex). Appropriate experiments have been made with single roughness elements in a plane channel flow to confirm these theoretical results.

J. O. Hinze, Holland

1956. Basin, A. M., Approximate investigation of the normal turbulent flow round a plate (in Russian), *Trudi Leningrad In-ta Inzb. Vod. Transp.* no. 22, 11–16, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8029.

The turbulent flow round a plate by an incompressible liquid is investigated. To define the outline of velocities in the path the following expression is adopted

$$u_1 = (v_0 - u_m)\,[1-(y/\delta)^n] \qquad [1]$$

where $u_1 = v_0 - u$, u_m is the value of u_1 on the axis, v_0 is the velocity of the stream outside the flow; u is the longitudinal composing the stream velocity inside the flow; δ is some conditioned thickness outside the flow. The velocity expression [1] is substituted in the integral equation of impulses and a single equation is arrived at with two unknowns, δ and u_m. Arguing from the fact that the value of the longitudinal component of velocity in the flow at some distance from the plate is equal, according to the order of magnitude, to the value v_0, while the value of the transverse component of velocity is equal, according to the order of magnitude, to the mean value of velocity u_1, author concludes that $(d\delta/dx) = (u_{cp}/v_0)$ [2], where u_{cp} is the mean value of velocity u_1. Having solved the equations dealing with δ and taking n to be equal to 1/11, author obtains the following final formulas:

$$\delta = \sqrt{\delta_0^2 + L\zeta x} \qquad \left(\zeta = \frac{Rf}{\frac{1}{2}\rho v_0^2 L}\right)$$

$$\frac{u_m}{v_0} = \left(1 + \frac{x}{L}\,\frac{1}{36\zeta}\right)^{-1/2}$$

Here δ_0 is the thickness of the boundary layer in the end of the plate; L is the length of the plate; ζ is the resistance coefficient of the plate. Results are given for the calculation of a numerical example.

V. M. Kuptsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1957. Vuliss, L. A., and Leontieva, T. P., Uniflow and counterflow turbulent jets (in Kazakhstan), *Izv. Akad. Nauk KazSSR, Ser. Energ.* no. 9, 109–122, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6876.

The approximate method of the superposition of currents is applied to the solution of the problem of the mixing zone of two plane flows in the case of uniflow and counterflow, respectively; the propagation of an axially symmetrical source-flow in the uniflow and counterflow cases; and the opposed motion of two axially symmetrical flows.

Authors attempt to verify experimentally the last two problems, the experiments having been made in a very narrow range of velocities of both flows.

A comparison of the theoretical calculations with the experimental results has enabled conclusions to be drawn concerning the qualitative agreement between the analytical and the experimental flow patterns.

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1958. Konovalov, I. M., The theory of turbulent jets (in Russian), *Trudi Leningr. In-ta Inzb. Vod. Transp.* no. 23, 3–9, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6878.

The equation of a two-dimensional turbulent flow derived by the author in the form

$$\frac{\partial \epsilon}{\partial(x^2)} = a^2\,\frac{\partial^2 \epsilon}{\partial y^2} \qquad \left(\epsilon = \frac{v^2}{2g} + \frac{\rho}{\gamma}\right)$$

in which ϵ = total energy and a^2 is a constant, is applied to the solution of the problem of the velocity distribution in a turbulent boundary layer of the flow round a two-dimensional body. A method is described for determining the value of the constant a from experimental data. It is proposed that the solution be utilized for the construction of the velocity field at the surface, and in the wake behind the body, and for determining the point of breakaway of the boundary layer.

The derivation is also described of the formula for turbulent friction proposed by the author in the form

$$\tau_{xy} = -\rho a^2 x\,\frac{\partial v^2}{\partial y}.$$

V. S. Avduevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1959. Kudryavtsev, P. I., The application of the hypothesis of similarity and the theory of dimensions in the study of an even turbulent flow (in Russian), *Trudi Novosibir. Inzb. Stroit. In-ta* **5**, 3–58, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5735.

A detailed analysis is given of the formulas for the distribution of velocities and the principle of resistance corresponding to the semiempirical theories of Prandtl and Karman. An attempt is made to evaluate the influence of viscosity with the help of the hypothesis of similarity of the averaged velocities. The similarity is examined in cases of nonautomodelling and automodelling regions. As a result formulas are derived which contain new empirical constants.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Aerodynamics

(See also Revs. 1911, 1939, 1995, 1996, 2009, 2012, 2014, 2016, 2086, 2099, 2120)

1960. Yoshihara, H., Kainer, J., and Strand, T., On optimum thin lifting surfaces at supersonic speeds, *J. Aero/Space Sci.* 25, 8, 473–479, Aug. 1958.

With the usual linearized supersonic theory, wings of given planform and zero thickness are derived which have minimum drag for prescribed values of lift and pitching moment. The required wing twist and camber are represented as a summation of ten quasi-conical expressions, and the coefficients of this series are determined by the usual calculus of variations. The harmonic method of Nikolsky, Kogan, Germain, and Graham is then used to determine the theoretically possible drag reduction to check the adequacy of the ten-term series. Planforms analyzed by the two methods are delta and sweptback wings with both subsonic and supersonic edges. Results indicate very large gains in $(L/D)_{max}$ for specific planforms.

From authors' summary by A. von Baranoff, France

1961. Katzen, E. D., Idealized wings and wing-bodies at a Mach number of 3, *NACA TN* 4361, 6 pp. + 10 figs., July 1958.

Calculations of lift-drag ratios for delta and arrow wings at Mach number 3 with assumed $c_{d_{min}}$ are compared with experiment. Wind-tunnel tests show maximum L/D value of 9 compared with a calculated value of 11. The main difference probably arises through an error in the assumed $c_{d_{min}}$. Results of visual flow studies using liquid film and vapor screen techniques show the trailing vortex system.

A. M. Kuethe, USA

1962. Gates, O. B., Jr., and Woodling, C. H., A theoretical analysis of the effect of engine angular momentum on longitudinal and directional stability in steady rolling maneuvers, *NACA TN* 4249, 13 pp. + 1 table + 5 figs., Apr. 1958.

Because the behavior of some aircraft depends on the direction of roll, authors extend Phillip's analysis [AMR 1 (1948), Rev. 1158] to include effect of engine angular momentum and conclude that the ranges of rolling velocity which induce aperiodic divergences may be increased thereby. Divergence boundaries are plotted as functions of two dimensionless frequency parameters for statically stable aircraft. This method necessitates relatively simple constructions for each rolling velocity and may be useful in project design.

Assumptions made to linearize the equations of motion in terms of incidence, sideslip, rate of pitch, and rate of yaw are explained clearly.

S. Kirkby, England

1963. Fauquet, A., Limits of application of lifting-line theory to the calculation of wings equipped with spoilers (in French), *Pub. Sci. Tech. Min. Air, France* no. 120, 56 pp. + 30 figs., 1957.

A systematic experimental investigation was carried out to study the application of Prandtl's lifting-line theory to wings equipped with spoilers, as developed in the author's previous work. Rectangular wings of aspect ratio 5, 4, and 3 are studied with spoilers located at 10, 20, 30, 40, 60, and 80% chord from the leading edge. The original method of analysis has been simplified through a critical study of the experimental results. Comparisons show that the drag, lift, and yawing moments can be accurately calculated for aspect ratios of 3 or higher provided the spoilers are more than 35% chord behind the leading edge. The calculation of rolling moments is limited to spoilers aft of 60% chord. The pitching moment apparently cannot be calculated with this theory.

A. H. Sacks, USA

1964. Patterson, Elizabeth W., and Braslow, A. L., Ordinates and theoretical pressure-distribution data for NACA 6- and 6A-series airfoil sections with thicknesses from 2 to 21 and from 2 to 15 percent chord, respectively, *NACA TN* 4322, 3 pp. + 44 figs., Sept. 1958.

Information is presented with which ordinates can be easily obtained for any thickness from 2 to 21% chord for NACA 63-, 64-, and 65-series airfoil sections and from 2 to 15% chord for NACA 63A-, 64A-, and 65A-series airfoil sections. In addition, data required for estimation of the theoretical pressure distributions of any of these airfoils are included.

From authors' summary

1965. Lock, R. C., A theoretical and experimental investigation of the flow over a family of rectangular wings of biconvex section at M = 1.42, *Aero. Res. Counc. Lond. Rep. Mem.* 3055, 43 pp., 1958.

An account is given of experiments made at $M = 1.42$ using three rectangular half-wing models having biconvex sections with thickness ratios 0.04, 0.06 and 0.08, mounted on a reflection plate. Measurements were made of the pressure on the upper surface of the wing and of pressure and flow direction in the neighborhood of the wing tip. Direct shadow photography and observation of surface oil patterns enabled various details of the flow to be visualized. The results are correlated with the linearized theory and with certain second-order modifications to this theory. It is found that in general the linearized theory provides a sufficient approximation to the detailed flow only for the thinnest wing at very small incidences. In most cases the suggested modifications effect a considerable improvement.

From author's summary by R. C. Roberts, USA

1966. Woods, L. C., Some contributions to jet-flap theory and to the theory of source-flow from aerofoils, *Aero. Res. Counc. Lond. Curr. Pap.* 388, 32 pp. + 12 figs., 1958.

Paper presents a theoretical study of the thrust, lift and moment on an airfoil due to a two-dimensional jet of air ejected from the trailing edge at an angle to the main stream. Applying the momentum equation, author shows that the thrust on the airfoil resulting from the jet is independent of the angle of ejection τ provided the jet does not mix with the main stream.

The theory of lift and moment, for incompressible flow, assumes that the jet is a distinct stream of fluid separated from the mainstream by two vortex sheets which can then be replaced in the flow equation by a single vortex sheet. Furthermore, the flow equation assumes that a jet of given momentum and angle τ influences the main stream the same as would a source-type flow with equal momentum and τ.

Conclusions are that airfoil C_L is proportional to $\tau(C_J)^{1/2}$ where C_J is the moment coefficient of the jet. The theory is in fair agreement with the experimental results available, although the dependence of C_L on τ has not been measured.

Paper contains appendices to clarify certain assumptions made and answer some criticisms of its contents.

R. E. Bolz, USA

1967. Shal'kin, N. D., Approximate theory for short taper wings (in Russian), *Trudi Novosibir. In-ta Inzb. Vod. Transp.* no. 2, 68-74, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7646.

A development is given of the approximate theory for short taper wings evolved by G. F. Burago [Work of the scientific-technical conference VVIA of Professor N. E. Zhukovskii, 1944, 1946, vol. 3] which is expressed in the more precise calculation of the values of the mean angles of taper from free and connected vortices. End formulas are brought in which permit obtaining the value of the angle of inclination of the free vortices and the coefficient of the lifting force by the method of successive approximations. As all the remaining assumptions and basic conditions of G. F. Burago's theory remain unchanged, the accuracy of the results calculated by the method proposed by Shal'kin may show

no improvement. No comparison is made with the experimental results. Abstractor notes that calculations by Burago's method give very good concordance with experiment, which excludes the practical necessity for further precision; in addition, the end formulas in the paper being abstracted have the appearance of being more complicated. S. I. Kuznetsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1968. Fraenkel, L. E., The wave drag of wing-quasi-cylinder combinations at zero incidence, *Aero. Quart.* **9,** 1, 55–70, Feb. 1958.

The subject topic is treated under the two assumptions that the surface slopes are sufficiently small for the application of linear theory and that it is sufficient to satisfy the body boundary condition on the surface of a circular cylinder. Three different drag formulas are derived. All are exact within the framework of linear theory for the restricted class of shapes considered. They are, moreover, algebraically and conceptually simple, but difficult to evaluate numerically. These results are used to make an order-of-magnitude analysis for wing-slender-body combinations. It is shown that a large number of terms are negligible when the ratio of body radius to wing chord is small, and the dominant terms for smooth bodies are those appearing in Ward's "area transfer rule." J. R. Spreiter, USA

1969. Lomax, H., and Heaslet, M. A., Recent developments in the theory of wing-body wave drag, *J. Aero. Sci.* **23,** 12, 1061–1074, Dec. 1956.

Analogous to the transonic area rule a supersonic area rule is presented. For this case authors give simple formulas for wave drag of combinations of thin wings and slender bodies, and show when they are admissible and when they fail. For the latter case, examples are given and comparisons are made between supersonic area rule and linearized theory, showing large discrepancies. Some other remarks refer to the method of multipoles along the axis of a cylinder. But this method is restricted to a certain class of bodies and, in general, the optimum fuselage to harmonize with a given wing cannot be found in this way. After reviewing the role of linearized theory in the limiting case $M \rightarrow 1$, further remarks on nonlinear transonic theory relate the drag of wing-body configurations with the drag of an equivalent body of revolution. F. W. Riegels, Germany

1970. Spreemann, K. P., and Sherman, I. R., Effects of ground proximity on the thrust of a simple downward-directed jet beneath a flat surface, *NACA TN* 4407, 11 pp. + 21 figs., Sept. 1958.

An investigation to determine the effects of some of the basic parameters on the thrust of a simple downward-directed jet beneath a lifting surface has been conducted in a static thrust facility at the Langley Aeronautical Laboratory. Some of the principal variables investigated were size and shape of the lifting surface and distance of lifting surface and nozzle exit above the ground. Devices to minimize the negative induced lift in close proximity to the ground also were investigated, and of all the devices tested a perforated plate raised slightly above the ground was the most effective. From authors' summary

1971. Hammack, J. B., and O'Bryan, T. C., Effect of advance ratio on flight performance of a modified supersonic propeller, *NACA TN* 4389, 7 pp. + 8 figs., Sept. 1958.

Results of a flight investigation of a modified supersonic propeller at the design Mach number of 0.95 indicated a propeller efficiency of approximately 79%. The departure from optimum angle of advance has a small effect for the advance ratios investigated. From authors' summary

1972. Tapscott, R. J., Some static longitudinal stability characteristics of an overlapped-type tandem-rotor helicopter at low airspeeds, *NACA TN* 4393, 14 pp. + 2 tables + 10 figs., Sept. 1958.

Comparisons of the flight measurements of some longitudinal characteristics with estimates of the characteristics based on theoretical interference effects show that the large undesirable trim change with power found in a particular range of conditions can be studied to advantage by using available information on interference effects between rotors. From author's summary

1973. Rhyne, R. H., Measurements of the motions of a large swept-wing airplane in rough air, *NACA TN* 4310, 11 pp. + 2 tables + 8 figs., Sept. 1958.

Results of a flight investigation of the angular and linear motions of a large swept-wing airplane in rough air for altitudes of 5000 and 35,000 feet are summarized in the form of sample time histories, power spectra, root-mean-square values, and probability distributions. From author's summary

1974. Westerwick, R., The roll coupling problem—a mathematical approach, *Aero. Engng. Rev.* **16,** 12, 48–51, Dec. 1957.

Roll coupling is analyzed using only linearized equations and including predominant cross-coupling terms. The resulting equations are split up into steady-state equations and stability equations. The latter are solved to determine the dependence of stability on rate of roll. Conclusions agree with those of simpler approach of Phillips [*NACA TN* 1627]. To improve stability of roll, decrease Cm_α or increase Cn_β.

The effects of various automatic controls are considered. Inertia coupling can be alleviated by gearing elevator to rate of pitch, the strength of the gearing being proportional to the square of the rate of roll. A. W. Babister, Scotland

1975. von Glahn, U. H., Use of the Coanda effect for jet deflection and vertical lift with multiple-flat-plate and curved-plate deflection surfaces, *NACA TN* 4377, 26 pp. + 2 tables + 15 figs., Sept. 1958.

Deflectors consisting of two, three, six and nine flat plates and curved plates, all using the Coanda effect for achieving jet deflection and lift, were tested in quiescent air. Ratios of lift to undeflected thrust somewhat less than those theoretically calculated for multiple-flat-plate and perfect curved-plate mechanical deflectors were obtained for the Coanda nozzles. With a 90° deflection of the jet stream, ratios of lift to undeflected thrust near 0.88 for a configuration using nine flat plates and near 0.81 for a curved-plate configuration were obtained together with zero axial thrust. From author's summary

1976. Hayes, W. C., Jr., Kuhn, R. E., and Sherman, I. R., Effects of propeller position and overlap on the slip-stream deflection characteristics of a wing-propeller configuration equipped with a sliding and fowler flap, *NACA TN* 4404, 12 pp. + 40 figs., Sept. 1958.

This investigation was made in a static-test facility at the Langley Laboratory. Lowering the thrust axis reduces the diving moments by virtue of the direct moment applied when the thrust vector passes below the moment reference point. Little or no change in the aerodynamics of the configuration arising from either vertical or chordwise changes in the position of the propeller was noted. Overlapping the propellers produced significant increases in thrust recovery at the highest flap deflection; however, these gains were greatly reduced by a corresponding loss in propeller static-thrust efficiency. The effects of number of propellers, flap segmentation, nacelle size, and a leading-edge slat were also investigated. From authors' summary

Vibration and Wave Motions in Fluids

(See also Revs. 1908, 2146)

1977. Miles, J. W., On the generation of surface waves by shear flows, *J. Fluid Mech.* **3,** 2, 185–204, Nov. 1957.

A mechanism for the generation of surface waves by a parallel shear flow $U(y)$ is developed under the following assumptions (among others): (1) The air, assumed incompressible and inviscid, has a prescribed mean shear flow; (2) The wave motion of water is its only motion and is irrotational, and the waves have small slopes; (3) All fluctuations consequent to the wave motion are small enough to permit the linearization procedure; (4) Only that component of the aerodynamic force that is in phase with the wave slope is regarded as important; and (5) The effect of turbulent fluctuations can be neglected. It is found that the rate at which energy is transferred to a wave of speed c_r is proportional to $-U''(y)$ at the elevation where $U = c_r$, and that the minimum wind speed for initiation of gravity waves against laminar dissipation in water without mean motion is roughly 100 cm/sec. Comparison of derived results with measurements show agreement in orders of magnitude.

Assumption (4), together with the tacit assumption that the imaginary part (c_i) of the complex wave velocity c is small, is the basis of the whole theory. It enables the author to take c_r to be approximately equal to the free-surface wave velocity c_w. The assumption that c_i is small then enables the author to find an approximate c_i (which is roughly proportional to the author's β), upon which subsequent developments depend. After this c_i is determined for the air, it is combined with the corresponding quantity for water (available from classical hydrodynamic theory) to find the total growth (or damping) factor. Of course, whether c_r is really approximately equal to c_w can only be answered by solving the complete eigenvalue problem or by experiment. The approximate equality of c_r and c_w is, however, a plausible assumption.

The paper is hard to read not only because the reader must keep alert in following the author through his assumptions and judgments, but also because at times the writing lacks clarity. Following (3.7), author tries to justify the imposition of (3.7) at $y = y_0$ instead of at $y = y_0 + \eta$. This is a minor offense everybody commits once he has succumbed to the sin of linearization. Author warns that ignoring η may have serious effects because the velocity variation over a distance comparable with η may be quite large. The subsequent justification for imposing (3.7) at $y = y_0$ is, however, not convincing. In this justification (p. 191) author states that the interface is a streamline. But it cannot be a streamline unless there is strictly neutral stability and a set of coordinates moving with speed c_r is used. Furthermore, even if the author can convince the reader that no great error is committed by assuming (for a moving coordinate system) the interface to be a streamline, he has yet to show that imposing (3.7) at $\psi = \psi_0$ is the same as imposing (3.7) at $y = y_0$. In another instance of obscurity (p. 201) θ_0 is not defined explicitly. In still another instance (p. 202) author tells the reader to use the β values given in figure 3, but to use $\beta = 0$ for $c < 3U_1$, in contradiction to figure 3. No explanation is given.

Imperfections notwithstanding, the paper contains many good ideas, presents an interesting point of view, and represents a plausible theory that contributes to the understanding of the phenomenon of wave generation by wind. C. S. Yih, USA

1978. Pearson, J. R. A., On convection cells induced by surface tension, *J. Fluid Mech.* **4,** 5, 489–500, Sept. 1958.

Author shows that the variations in surface tension produce variations in surface tractions which can induce a cellular convective motion even when the buoyancy is insufficient to do so. The results indicate that cells of the type observed by Benard arise from surface tension. M. Tribus, USA

1979. Mashkovich, L. A., The hydraulic jump in a trapezoidal channel (in Russian), *Trudi Tashkentsk. In-ta Inzh. Irrigatsii i Mekhaniz. S.-kh.* no. 2, 137–143, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6686.

Results are presented of investigations on the hydraulic jump in a trapezoidal channel with a coefficient of inclination of the side walls of 1.5.

It is pointed out that the jump has in this case a greater length than in a rectangular channel, and, differing from the latter, is characterized by the presence of lateral whirlpools (eddies) and reflux currents. This length l the author considers can be determined for values of the Froude number Π exceeding 15 (referred to the constricted cross section) by the formula of M. D. Chertoussov ["Special course of hydraulics," 26, 1949]

$$l = 5b'' \left[1 + 4\left(\frac{B''}{B_c} - 1\right)^{1/2}\right]$$

(B''/B_c = ratio of the "conjugate" widths along the surface of the flow), and the eddy length by the equation of M. S. Vyzgo:

$$\frac{l}{b'' - b_c} \approx 0.3\ (\Pi + 40)$$

The values of the conjugate depths b'', calculated by the law of quantity of motion, agree well with the experimental results.

V. V. Smyslov

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1980. Aronovitch, G. V., The influence of hydraulic shock (water hammer) on natural vibration in the governing of hydraulic turbines (in Russian), *Uch. Zap. Gorkovsk. In-ta* **30,** 193–205, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6650.

The self-induced vibrations of a speed-governing system for a separately working hydraulic turbine generator unit are examined. All linkages in the system are assumed to be linear, with the exception of the servomotor, the speed of which is assumed to be proportional to the discontinuity function $f(\sigma)$ of the displacement of the slide valve α in one of two forms corresponding to the case of a so-called constant speed servomotor (which is a somewhat rough equivalent to the real servomotors used in hydraulic turbines) with negative and positive lap in the slide valve.

The system investigated is reduced to a system consisting of a relay with the characteristic $f(\sigma)$ and a linear linkage with a transmission coefficient of $K = K(p)$, incorporating the whole linear part of the system (the method proposed by the author is applicable to any system which can be reduced to such a form). Applying the theory of relay systems developed by Yu. I. Neumark and expanding $K(p)$ in series by the simplest fractions, the possibility is demonstrated of periodic systems, and the construction of their range of existence is explained. The cases are examined of a rigid (K = fractionally-rational function of p) and an elastic (K = meromorphous function of p) water hammer, and the material influence of wave phenomena in the pipeline on states of natural vibration is demonstrated for the cases when the phase of the water hammer and the time constant of the pipeline are values of the same order of magnitude. N. A. Kartvelishvili

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1981. Vasil'ev, O. F., Hydraulic jump and spreading of flow in a widening bed (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* **106,** 797–800, Feb. 1956.

1982. Kuzmenkov, V. I., Some types of energy damping in the conditions of the three-dimensional problem of conjugate pounds (in Russian), *Sb. Nauch. Rabot Beloruss. Politekhn. In-ta* no. 54, 71-77, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6692.

1983. Belotserkovskii, S. M., Representation of non-stationary aerodynamic moments and forces by means of coefficients of rotational derivatives (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 53-70, July 1956.

1984. Levkevich, E. M., Wave measurement by a wave-graph (in Russian), *Sb. Nauch. Rabot. Belorus Politekh. In-ta* no. 54, 98-103, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4317.

Fluid Machinery

(See also Revs. 1906, 1910, 2063, 2100, 2106)

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A simple equation expressing the wake momentum thickness as a primary function of the suction-surface diffusion ratio (ratio of maximum surface velocity to outlet velocity) of conventional low-speed cascade blades is derived from boundary-layer theory in conjunction with simplifying approximations. The derived equation is utilized to gain an insight into qualitative effects on stalling diffusion ratio of such factors as Reynolds number, transition location, and extent of local laminar separation. Use of parameters suggested by the analysis is shown to result in generalized experimental loss and stall correlations and in means for estimating total-pressure loss and unstalled range of operation for commonly used blades. From author's summary

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Starting with the von Karman momentum equation, a simple analytical relation between blade-wake momentum thickness and suction-surface diffusion ratio is derived by introducing simplifying approximations and empirical constants. The obtained relation describes experimental correlation well. The derived equation is used to investigate qualitative effects of such secondary factors as Reynolds number, surface roughness, transition location and local laminar separation on the variation of wake momentum thickness with diffusion ratio. Results indicate that blades should be designed for low friction coefficient and minimum laminar flow if maximum allowable values of suction-surface diffusion ratio are desired. H. Bergh, Holland

1987. Isay, W.-H., Computational results of radial flow in cascades of airfoils (in German), *ZAMM* **38,** 5/6, 209-220, May/June 1958.

Detailed numerical examples of cases (a) and (c) of AMR 8 (1955), Rev. 1058. G. Moretti, USA

1988. Dombrovskii, G. A., On subsonic flow with free streamlines past a cascade of flat plates (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **111,** 2, 312-315, Nov. 1956.

In full analogy to the method presented in the paper "Approximate solution..." [title source **107,** 6, 799-802, Apr. 1956] another form of approximating function has been introduced into Chaplygin's equations, and solutions of the approximate equations obtained in this way have been given in closed form. These solutions have been applied, by means of suitable conformal mapping, to the special case of flow, i.e. the subsonic flow past a cascade of straight line airfoils with free streamlines going from the leading and trailing edges of every airfoil.

W. Prosnak, Poland

1989. Frenkel, M. I., Methods of comparing self-acting valves by their static characteristics (in Russian), *Sb. Statey Vses. N.-i. i Konstrukt. In-ta Khim. Mashinostr.* no. 18, 36-56, 1954; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6554.

A method is developed for comparing the static characteristics of self-acting valves used in piston compressors. On the basis of hydraulic conceptions of the flow through valves, it is suggested that different types of valves be compared according to the degree of utilization of the cross section of the inlet passages for the gas flow.

The valves are compared on the basis of an experimental test made in conditions of a steady flow through the valve. The influence of the dynamic characteristics of the valve on its action is not considered. M. Ya. Yudelovich

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1990. Kovats, A., Calculation of radial-flow-impeller performance curves by the modified aerofoil theory, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-86, 16 pp.

The modified airfoil theory is generally used for the calculation of axial-flow impellers; however, this method is seldom applied to calculate radial-flow impellers. The method as described in this paper makes it possible to predict the performance curve of radial-flow impellers, and it is shown by test results that the calculated curves coincide closely with the measured performance curves.

From author's summary

1991. Rains, D. A., Head-flow characteristics of axial flow helical inducers, *Jet Propulsion* **28,** 8 (part I), 557-558 (Technical Notes), Aug. 1958.

Recent tests have shown that high solidity helical inducers are capable of operating without large loss in efficiency at suction specific speeds of 25,000-35,000. These inducers, therefore, have many possible applications in high-speed pumps. This note was prepared to present several methods of computing the ideal head-flow characteristics of axial flow helical inducers and to compare these results with experimental data.

From author's summary

1992. Lomakin, A. A., Methods for designing efficient high-speed axial pumps, hydraulic turbines and ventilators (in Russian), *Energomashinostroenie* no. 7, 1-6, July 1956.

Author claims that his paper provides method for calculating the performance characteristics of high-speed axial hydraulic and pneumatic machinery. He uses one-dimensional vector diagrams of velocities and derives from them analytically performance characteristics corrected for several types of losses found experimentally. Results are presented in the familiar form of efficiency versus velocity coefficient as a function of various parameters, such as volumetric flow, cavitation parameter, etc. On the basis of these graphs the author suggests several design approaches, including shapes of diffusors, which purport to maximize the efficiency of the unit.

Reviewer believes that this paper hardly adds anything new to the presently existing elementary engineering methods of performance calculation of axial turbomachinery. The analytical formulas on which some of the graphs are based are of dubious value since they contain empirical parameters not too well defined or understood to make their use possible for all sizes and shapes of axial turbomachinery. Judging from the appended bibliography author

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From author's summary

1991. Rains, D. A., Head-flow characteristics of axial flow helical inducers, *Jet Propulsion* **28,** 8 (part 1), 557–558 (Technical Notes), Aug. 1958.

Recent tests have shown that high solidity helical inducers are capable of operating without large loss in efficiency at suction specific speeds of 25,000–35,000. These inducers, therefore, have many possible applications in high-speed pumps. This note was prepared to present several methods of computing the ideal head-flow characteristics of axial flow helical inducers and to compare these results with experimental data.

From author's summary

1992. Lomakin, A. A., Methods for designing efficient high-speed axial pumps, hydraulic turbines and ventilators (in Russian), *Energomashinostroenie* no. 7, 1–6, July 1956.

Author claims that his paper provides method for calculating the performance characteristics of high-speed axial hydraulic and pneumatic machinery. He uses one-dimensional vector diagrams of velocities and derives from them analytically performance characteristics corrected for several types of losses found experimentally. Results are presented in the familiar form of efficiency versus velocity coefficient as a function of various parameters, such as volumetric flow, cavitation parameter, etc. On the basis of these graphs the author suggests several design approaches, including shapes of diffusors, which purport to maximize the efficiency of the unit.

Reviewer believes that this paper hardly adds anything new to the presently existing elementary engineering methods of performance calculation of axial turbomachinery. The analytical formulas on which some of the graphs are based are of dubious value since they contain empirical parameters not too well defined or understood to make their use possible for all sizes and shapes of axial turbomachinery. Judging from the appended bibliography author

has made no use of non-Russian technical literature which deals with the subject of his paper in á more advanced and thorough fashion. B. Zarwyn, USA

1993. O'Bryan, T. C., Flight measurements of the vibratory stresses on a propeller designed for an advance ratio of 4.0 and a Mach number of 0.82, *NACA TN* 4410, 7 pp. + 6 figs., Sept. 1958.

The vibratory stresses on the propeller were low in relation to the strength of the material; maximum bending stress was ±3,700 pounds per square inch and maximum torsion stress was ±1000 pounds per square inch. From author's summary

1994. Kolpakov, L. G., Evaluation of the quality of grids of turbines in turbodrills (in Russian), *Trudī Mosk. Neft. In-ta* no. 16, 148–167, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7900.

Results are given for the calculation of the coefficient of loss of full pressure in the flat grid of profiles of the working wheel of a turbine in series of a turbodrill and in the theoretical grid, constructed to meet the same conditions. The distribution of velocity in the potential flow of incompressible liquid on the grid profile was obtained by the method set out in L. A. Dorfman's paper [Heat transfer and aero-hydrodynamics, *TsKTI*, 1952, Kn. (22)]. The coefficient of loss is determined with the aid of the calculation for the boundary layer at the outlet edge using the L. G. Loitsianskii method [*Prikl. Mat. Mekh.* **9**, no. 6, 1945]. It was shown that the grid with theoretical profiles had some advantages. In contradistinction to the standard evaluations of grid quality the paper deals with producing the k.p.d. (coefficient of useful work) on the surrounding force p, while when calculating the k.p.d. the losses of full pressure are referred to the axial force. There is an incorrect assertion, namely that there are no reliable data on the established system of selection of parameters for the theoretical grids. V. L. Epshtein

Courtesy Referatnyt Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1995. Emmons, H. W., Kronauer, R. E., and Rockett, J. A., A survey of stall propagation—experiment and theory, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-150, 8 pp.

The experimental literature on stall propagation is summarized in terms of an idealized compressor which possesses properties typical of the bulk of published data. The published analyses are examined and all are shown to have one fundamental restriction or another which makes them unable to predict all of the relevant features of stall propagation—most notably the number of stall cells. A relatively simple mathematical model is constructed which offers the possibility of a complete prediction. From authors' summary

1996. Rockett, J. A., Modulation phenomena in stall propagation, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-152, 9 pp.

Recent experimental work on stall propagation in a single-stage research compressor is described. At certain fixed operating points, several different stall patterns were found to exist. Transitions from one pattern to the other occurred spontaneously, reversibly, and fairly frequently. These transitions were studied in detail. A regular modulation of the stall-propagation velocity is associated with the transition process. The modulation is used to determine stall frequency as a function of both wave number and mass flow. Stall-cell size measurements, static-pressure surveys, and a study of the region downstream of the stall-propagating rotor are described. From author's summary

Flow and Flight Test Techniques and Measurements

(See also Revs. 1679, 1902, 1917, 1923, 1976, 2065, 2073, 2075, 2106, 2108)

1997. Pope, K. E., A new double-integrating accelerometer, *Control Engng.* **5,** 11, 97–100, Nov. 1958.

Measuring acceleration in inertial guidance systems is not an end in itself. To be of use, the measured acceleration must be integrated at least once—to give vehicle velocity—and possibly twice—to give distance traveled and vehicle position. There are many nonintegrating accelerometers that will give an output accurate to 0.1% or better of full scale, but inaccuracies are introduced in the electronic integration process that must follow—as much as 3% over-all velocity error and 5% over-all distance error.

The torsion reaction accelerometer gets around this excessive integration error by measuring acceleration and performing two time integrations in the basic accelerometer. Current models are accurate to within 0.5% and an accuracy of 0.1% does not seem beyond reach. Too, this accelerometer simplifies the system by eliminating two stages of electronic integration and by providing a pulse-train output signal. Telemetering is easy, since velocity is proportional to pulse frequency (and inversely to pulse width) and distance traveled is proportional to the number of pulses. From author's summary

1998. Kardos, G., Tests on deflection of flat oval Bourdon tubes, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-67, 6 pp.

To fill the gap in knowledge of Bourdon tube deflection data, the method and results of tests on 70 varied flat oval Bourdon tubes are given. The results are compared against published design data. The results are evaluated to determine the function of the deflection with respect to geometric parameters. From author's summary

1999. Jacobs, R. B., Martin, K. B., and Hardy, R. J., Direct measurement of net positive suction head, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-38, 4 pp.

A simple, reliable, and accurate method for measuring net positive suction head is described, difficulties which may be encountered in its application are discussed, and test information indicating its reliability and accuracy is presented. The device which embodies the method consists of a vapor-pressure bulb that measures the vapor pressure of the liquid, a pressure tap that measures stagnation pressure, and a pressure gage to indicate (and record, if desired) the difference between the two pressures. From authors' summary

2000. Warschauer, D. M., and Paul, W., High-pressure techniques, *Rev. Sci. Instrum.* **29,** 8, 675–679, Aug. 1958.

Paper supplies information on hydrostatic pressure techniques up to 20,000 kg/cm² under two headings. Under general pressure techniques, low temperature seals, experience with small diameter tubing, a pressure measuring bridge, and various tubing seals are described. Under optical techniques, optical windows of sapphire, germanium, and silicon, suitable pressure fluids, and a mechanism for moving samples inside a pressure vessel for use to 10,000 kg/cm² are discussed. From authors' summary

2001. Kemp, J. F., Centrifugal manometer, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-111, 8 pp.

The operating principles and mechanical construction of a micromanometer, which utilizes air in lieu of a liquid as working fluid, are described. Some of the noteworthy features of the in-

strument include its high sensitivity and accuracy, quick response, wide range, and ease of manipulation. Differential pressures of the order of 5×10^{-3} mm water gage can be measured with an error of 1% under normal laboratory conditions. The maximum range of the prototype described is 25 mm water gage, and the corresponding error at this value amounts to about 0.25%.

From author's summary

2002. Fetisov, M. M., Utilization of inductive transformers for the measurement of nonstationary pressures (in Russian), *Trudi Leningr. Politekhn. In-ta* no. 176, 214–227, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5846.

The method of calculation and the construction of inductive transformers is examined. The conditions are checked which enable observations to be made insuring the obtaining of the maximum relative sensitivity of one of the most important parameters of the transformer. Directions are given regarding the transformer connections to the load of a finite resistance and to the load of an infinitely large resistance (to a valve amplifier). Constructional details are given for transformers for the measurement of fluctuating pressures using or not using amplifiers. The lay-out and description of building one of the model differential, induction low-clearance transformer are submitted; this is intended for work with amplifying apparatus. The clearance dimensions of this transformer are 11 × 9 mm, and this enables very small pressures to be measured. For instance, with a membrane thickness of 0.03 mm and original clearance of 0.1 mm, vibrator-type VIII of oscillograph MPO.2 gives a full declination at a pressure of 1.5 mm (water column). The graduated curve is linear over wide limits and the working voltage of the transformer at a frequency of the supplying current of 800 hertz is equal to 12 V on both induction coils. A diagram is given for the measuring device for the work of an induction transformer without amplifier, and also constructional details of such a transformer. This transformer can be successfully used for measuring variable pressures of gases and liquids in very wide limits, from 10 m to 15 m (water column) depending on the membrane thickness. The transformer possesses a sufficiently high sensitivity and its graduated curve is practically linear. In conclusion the paper refers to several possible schemes of compensation for a large constant component of pressure when measuring the small variables of the pressures of gases and liquids.

N. A. Preobrazhenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2003. Rowe, P. N., Laboratory methods of measuring thrust, I and II, *Engineer, Lond.* **205,** 5344, 964–972, June 1958; **206,** 5345, 4–6, July 1958.

2004. Numachi, F., Yamabe, M., and Oba, R., Cavitation effect on the discharge coefficient of the sharp-edged orifice plate, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58–A–93, 6 pp.

The object of this paper is to investigate the effects of cavitation on the discharge coefficient of sharp-edged orifice plates with reference to various degrees of cavitation as defined by a cavitation number. The experimental data described in this paper substantiate the fact that cavitation can exist to a minimum cavitation number of 0.2 without introducing errors in the orifice discharge coefficient in excess of the normal expected accuracy. In addition to this, it was found that the use of air-inhalation to suppress the vibration and noise from the cavitation had no effect on the discharge coefficient.

From authors' summary

2005. Katys, G. P., Apparatus for the measurement of a rapidly changing discharge of liquid (in Russian), *Izmerit. Tekhnika* no. 4, 87–91, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8121.

Working principles are described and a comparison made of new type measuring apparatus, perfected and applied in investigational practice for the measurement of rapidly changing discharges of liquid. Turbine discharge meters are investigated (electromagnetic and photoelectrical), and also mass-type, ultrasonic, ionizing and induction discharge meters. It is notable that the smallest inertia capacity is possessed by the ultrasonic discharge meter; its limit of measurable frequency of discharge change with electronic commutation comprises tens of kilohertz with an unlimited range of discharges. For an induction discharge meter with a variable magnetic field the limit of measurable frequency is equal to 500/hertz, for mass-type meters 300 hertz, for discharge meters of other types 30–100 hertz. Induction and ultrasonic discharge meters appear to have the best prospects. The ultrasonic discharge meter permits the measurement of liquid discharge with any physico-chemical properties, while the induction type is the best for measuring liquid discharge with electroconductivity higher than 10^{-8} mom/cm^3.

T. B. Kurova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2006. Altschul, A. D., Measurement of the flow through a pipeline by measuring the pressure at a single point (in Russian), *Izmerit. Takhnika* no. 3, 40–42, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6641.

An examination is made of the well-known proposition of the possibility of determining the volume of flow of a gas or a liquid by measuring the velocity at a single point. The point selected is located where the flow velocity has a mean value, and cylindrical pressure heads are used; for a laminar flow, at the point $y_\nu = 0.293r$, for a turbulent flow, at $y_\nu = 0.223r$. As a confirmation of the correctness of the recommended relationship for turbulent motion, a curve is presented of $y_\nu = f(\log R)r$, where R is the Reynolds number, on which are plotted the points obtained by evaluation of Nikuradse's experimental data for smooth and rough tubes, and the experimental points Φ of F. A. Shevelev for tubes of different diameters with a naturally rough surface. It is observed that Shevelev recommends using the relationship $y_\nu = 0.242r$. As a result of analysis of the experimental data, it is concluded that the position of the layer moving with mean flow velocity is constant, and that the relationship recommended by the author is practically correct over the whole range of Reynolds numbers.

The results of special tests are presented, showing that the divergence in the values of the mean velocity determined by the "uniflow" method and by measuring the mean velocity at 8 points on the cross section should not exceed 4%. It is remarked in this connection that perceptible deviations in the position of the point selected for measuring the mean velocity from the theoretical values given above produce only small variations in the magnitude of the flow volume measured. Author explains this by reference to the existence in the literature of different recommendations concerning the position of the point of mean velocity.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2007. Head, V. P., Electromagnetic flowmeter primary elements, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58–A–126, 7 pp.

An obstructionless flowmeter for electrically conducting liquids is described. Tentative design and inspection criteria which have been found to provide accuracies of ±½%, or as little as ±0.005 fps pipeline velocity, are set up. A practical threshold conductivity of meterable liquids is set at 20 micromhos per cm, though there is every reason to believe this will be drastically cut with further progress. Above this threshold, the flow coefficient in

the volume-rate equation is shown by tests to be independent of the conductivity, of the Reynolds number, and of installation conditions. From author's summary

2008. Kouyoumjian, W. L., and Hoffman, S., Free-flight investigation to determine the drag of flat- and vee-windshield canopies on a parabolic fuselage with and without transonic indentation between Mach numbers of 0.75 and 1.35, *NACA TN* 4405, 9 pp. + 3 tables + 18 figs., Sept. 1958.

Several rocket-propelled models of canopy-fuselage combinations were tested to determine the effect on total drag and pressure drag of canopy windshield shape, fineness ratio, and position along the axis of a parabolic body of revolution. The flat-windshield canopies investigated had over-all fineness ratios of about 7.00 and 4.50. The vee-windshield canopies tested had fineness ratios of about 7.00. Models of all the canopy-fuselage configurations with transonic-area-rule indentations were also tested. Experimental and theoretical pressure drag comparisons are made for about half the models investigated. The flight tests covered a Reynolds number per foot range from about 4.5×10^6 to 9.5×10^6 for the corresponding flight Mach number range of 0.75 to 1.35. From authors' summary

2009. Clevenson, S. A., and Leadbetter, S. A., Measurements of aerodynamic forces and moments at subsonic speeds on a simplified T-tail oscillating in yaw about the fin midchord, *NACA TN* 4402, 12 pp. + 1 table + 7 figs., Sept. 1958.

Coefficients which define rolling moment of the horizontal stabilizer alone and rolling moment, yawing moment, and side force of the complete T-tail are shown. In the investigation the range of reduced-frequency parameter was from 0.09 to 0.56, the Mach number range was from 0.13 to 0.50, and the Reynolds number range was from 0.90×10^6 to 8.21×10^6. Coefficients for the steady case (reduced-frequency parameter of zero) were calculated for the forces and moments and good agreement was indicated for all except the horizontal-stabilizer rolling-moment coefficient, which was found to be of greater magnitude than was indicated by steady-state results. From authors' summary

2010. Sibulkin, M., and Vrebalovich, T., Some experiments with a resonance tube in a supersonic wind tunnel, *J. Aero/Space Sci.* 25, 7, 465–466 (Readers' Forum), July 1958.

2011. d'Ewes Thompson, T. A., and Meyer, R. E., An experiment on compressible flow perturbations, AFOSR TN 58-447 (Brown Univ., Div. Appl. Math.; ASTIA AD 158253), 15 pp. + 7 figs., June 1958.

The effect which a slight tilting of the liners of a supersonic wind-tunnel nozzle has on the Mach number distribution in the test-rhombus is determined on the basis of the linear perturbation theory of the second author [*Aero. Quart.* **7**, 71–84, Feb. 1956; AMR **10** (1957), Rev. 488]. Experiments are reported which (1) confirm that the first-order subsonic and transonic perturbations of the flow may be neglected compared with the supersonic perturbations, and (2) indicate that appreciable effects not accounted for by the first-order theory occur when the flow possesses high local pressure gradients. From authors' summary

2012. Savin, R. C., Comparison of shock-expansion theory with experiment for the lift, drag, and pitching-moment characteristics of two wing-body combinations at M = 5.0, *NACA TN* 4385, 7 pp. + 5 figs., Sept. 1958.

Two wing-body combinations were tested in the Ames 10- by 14-in. supersonic wind tunnel. Lift, drag, and pitching-moment characteristics were determined at a Mach number of 5.0 and angles of attack up to 9°. Theoretical results obtained with the aid of the generalized shock-expansion method were compared with experiment. From author's summary

2013. Adams, R. H., A high temperature stream tube for a supersonic wind tunnel, Mass. Inst. Technol., Naval Supersonic Lab., Tech. Rep. 303, 121 pp., May 1958.

The increasing desirability of obtaining aerodynamic heating data at supersonic Mach numbers led to the development of a method of injecting a high-temperature stream tube into a supersonic wind tunnel. A "core" of high-temperature air injected slightly downstream of the throat of the Naval Supersonic Laboratory Supersonic Wind Tunnel's Mach 3.5 nozzle produces a relatively constant Mach number and temperature region in the 18-inch × 18-inch test section. This region of 900 F stagnation temperature air was approximately 7 inch × 7 inch and caused no appreciable heating of the tunnel structure. The 7 inch × 7 inch "hot" test area is approximately the blocking area of the test section. Thus by heating only one-sixth of the total mass flow of air in the test section the same aerodynamic heating models may be tested as if the entire mass flow were heated. From author's summary

2014. McKay, J. M., Sawyer, R. H., and Hall, A. W., Measurements of ground-reaction forces and vertical center-of-gravity accelerations of a bomber airplane taxiing over obstacles, *NACA TN* 4400, 10 pp. + 3 tables + 14 figs., Sept. 1958.

The obstacles were 1.5 and 3.0 inches in height and 1, 2, and 4 feet in width. The tests covered a range of ground speeds from 10 to 70 mph. Results are presented of the effects of ground speed and the widths and heights of the obstacles on the vertical and rearward drag ground-reaction forces, the vertical acceleration at the center of gravity of the airplane, the shock-strut displacement, and the dynamic response of the upper mass of the airplane structure. From authors' summary

2015. Weiberg, J. A., Griffin, R. N., Jr., and Florman, G. L., Large-scale wind-tunnel tests of an airplane model with an unswept, aspect-ratio-10 wing, two propellers, and area-suction flaps, *NACA TN* 4365, 16 pp. + 1 table + 26 figs., Sept. 1958.

An investigation was made to determine the effects of a propeller slipstream on the lifts obtainable and the flow requirements for suction applied to a porous area on a trailing-edge flap on a large-scale model of an airplane having a high-aspect-ratio, thick, straight wing. The propeller slipstream had no effect on the suction flow requirements but the suction pressures required increased with thrust coefficient. From authors' summary

2016. Williams, J., and Alexander, A. J., Pressure-plotting measurements on an 8 per cent thick aerofoil with trailing-edge flap blowing, *Aero. Res. Counc. Lond. Rep. Mem.* 3087, 13 pp. + 1 table + 22 figs., 1958.

Wind-tunnel experiments were carried out on an 8-per-cent thick airfoil between end plates, with blowing from a slot in the knee of a 25-per-cent chord trailing-edge flap, to improve the lifting efficiency of the flap. Both the blowing-slot width and position were varied. The sectional lift and pitching moment were derived by chordwise integration of the surface static pressures measured at the midspan station. Tuft observations as well as surface-pressure measurements were made to determine the extent of the turbulent separation region on the trailing-edge flap and of the laminar separation bubble on the airfoil nose.

The blowing momentum required to prevent flow separation on the flap, at a given flap angle and zero wing incidence, proved much less than might have been expected from earlier two-dimensional experiments on thicker wings with blowing over the flap from the shroud. This reduction is probably associated with the low effective aspect ratio of the present quasi two-dimensional model as well as with improvements in blowing techniques. The separation bubble on the airfoil nose began to expand markedly (with the flap deflected) when the incidence reached only a few

degrees, and simultaneously the blowing momentum needed to prevent flow separation on the flap tended to increase.

From authors' summary

Thermodynamics

(See also Revs. 1917, 1943, 2030, 2067, 2076, 2077, 2090, 2091, 2093)

Book—2017. Schmidt, E., Introduction to engineering thermodynamics and to fundamentals of chemical thermodynamics [Einfuhrung in die technische Thermodynamik und in die Grundlagen der chemischen Thermodynamik], Berlin, Springer-Verlag, 7th rev. ed., 1958, xvi + 528 pp. DM 30.

(See AMR **10** (1957), Rev. 1898; **7** (1954), Rev. 4009)

This German standard text of engineering-thermodynamics is revised to conform to the International System of units; mass is measured in kilograms whereas force is measured in Newtons, where one Newton is the force required to give an acceleration of one meter per second per second to a mass of one kilogram. Other additions and improvements noted by reviewer appear to be relatively minor. Printing and binding are of the high quality typical of Springer-Verlag. E. L. Knuth, USA

2018. Guggenheim, E. A., Thermodynamics of curved surfaces, *Research, Lond.* **10,** 12, 478–481, Dec. 1957.

It was Gibbs who first pointed out that the surface tension can be expressed simply in terms of temperature and the chemical potentials of the species of multicomponent systems for plane surfaces but the dependence of surface tension on the curvature of the interface is extremely difficult or impossible to determine. Many attempts have been made to present an exact and rigorous mathematical treatment of the latter condition. The result has been chaos. Professor Guggenheim has done a remarkable service in presenting a clear and unequivocal summary of the various approaches to the problem. His conclusion is that Gibbs was right. J. F. Lee, USA

2019. Ikenberry, E., and Truesdell, C., On the pressures and the flux of energy in a gas according to Maxwell's kinetic theory, I, *J. Rational Mech. Analysis* **5,** 1, 11–54, Jan. 1956.

2020. Truesdell, C., On the pressures and the flux of energy in a gas according to Maxwell's kinetic theory. II, *J. Rational Mech. Analysis* **5,** 1, 55–126, Jan. 1956.

2021. Gabbay, E. J., Open cycle refrigeration—the bootstrap refrigerator, *Aircr. Engng.* **30,** 349, 64–71, Mar. 1958.

Air-cycle "bootstrap" refrigeration principles are reviewed. Included are: Cycle theory, component processes, and calculations; use of auxiliary evaporative cooling; compressor and turbine characteristics and matching; calculation of duct losses with compressible flow; how equipment is generally sized for maximum speed and altitude, with consequent oversizing for lesser speeds and altitudes. Typical system and operating controls are described, particularly comparing pressure-ratio and variable-orifice control. System is limited to flight Mach numbers below about 2.5.

H. B. Nottage, USA

2022. Levental', G. B., and Melent'ev, L. A., Correlation between the thermodynamic and power indexes of heat-power plant efficiency (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 40–51, May 1956.

2023. Komarov, I. A., Calculation of turbine jets by means of the equation of the curve process (in Russian), *Sb. Nauch. Trudi Kuibyshchevsk. Industr. In-ta* no. 6 (part 1), 229–231, 1956; *Ref. Zh. Mekh.* no. 7, 1957; Rev. 7746.

An equation in terms of coordinates $s - i$ is given for the changes of the condition of gas or superheated steam while flowing through the jets of a gas or steam turbine. This equation permits the calculation of the plane of section of the channel and to compute more precisely the jet effect. The method proposed by the author appears to be approximate, as it is based on the arbitrarily accepted assumption of the constancy of velocity coefficient ϕ along the jet. V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2024. Guildner, L. A., The thermal conductivity of carbon dioxide in the region of the critical point, *Proc. Nat. Acad. Sci., Wash.* **44,** 11, 1149–1153, Nov. 1958.

Author uses a massive concentric cylinder-type cell with uniform conductivity gap of 0.06955 cm along vertical axis and at the bottom to determine thermal conductivity of CO_2 over the density range 0.3 to 0.8 g/cc and at 32.054 (critical), 34.7, 40.1, and 75.3 C. Some values at 30.9 C are given. Convection was controlled by careful experimental procedures. Thermal conductivities in the density range near the critical show marked increases for the three lowest isothermes above the critical.

J. A. Beattie, USA

2025. Heil, M., Kinetic theory of flows in dissociating gases (in German), *Brennstoff-Wärme-Kraft* **10,** 6, 298–299, June 1958.

Paper summarizes briefly a lecture of which full accounts are being published by G. Ludwig, H. J. Metzdorf and M. Heil, "Advances in Applied Mechanics," **6,** 1958, and by M. Heil, *J. Aero. Sci.* **25,** p. 459, 1958.

Author deals with transport coefficients in dissociating gases composed of diatomic molecules A_2. Approximate solutions of Boltzmann collision equations give macroscopic equations of motion, and also the transport coefficients. Thermal conductance passes through a maximum in the region of dissociation.

A. R. Ubbelohde, England

2026. Ishkin, I. P., and Kaganer, M. G., Investigation of the thermodynamic properties of air and nitrogen at low temperatures under pressure, Pt. 1., Determination of the isothermal choke effect for air and nitrogen (in Russian), *Zh. Tekh. Fiz.* **26,** 10, 2329–2337, Oct. 1956.

2027. Ishkin, I. P., and Kaganer, M. G., Investigation of the thermodynamic properties of air and nitrogen at low temperatures under pressure, Pt. 2., Thermodynamic phase diagrams for air and nitrogen (in Russian), *Zh. Tekh. Fiz.* **26,** 10, 2338–2347, Oct. 1956.

2028. Sirota, N. N., On the temperature dependence of the heat capacity of solids, *Soviet Phys.-Doklady* **2,** 4, 393–395, May 1958. [Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **115,** 1–6, 901–903, July–Aug. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)

A brief description is given of an extension of the Einstein and Debye relations for the specific heat capacities of solids using a near-Gaussian frequency distribution. The result is a simple expression, which gives good correlation with experiment, of the temperature dependence of various solids.

J. F. Lee, USA

2029. Sinel'nikov, N. N., and Filipovich, V. N., Adiabatic calorimeter—an apparatus for simultaneous determination of heat capacity and thermal conductivity, *Soviet Phys.-Tech. Phys.* **3,** 1, 193–196, Aug. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 1, 218–221, Jan. 1958, by Amer. Inst. Phys., Inc., New York, N. Y.)

Various means of determining the heat capacity, thermal conductivity and thermal diffusivity of materials inserted in a double-wall cylinder with both an internal-external heater are described. The thermal conductivity and heat capacity can be determined by one experiment and, hence, the thermal diffusivity calculated.

Experiments using powdered quartz are described and, in conjunction with tests in vacuum, the relative importance of radiation, heat conduction both by air and powder, and convection in the granular mass assessed. It is shown that the major heat transfer is by convection though the proportion decreases with rise in temperature.

Paper is hard to read, especially without an earlier paper which apparently covers much of the same ground. There appear to be some errors, possibly in translation, which add to the difficulties (cf. the definitions of N_1 given in the legend to Fig. 1 and the second paragraph of p. 195). It is also difficult to reconcile Figs. 1 and 2. G. G. Thurlow, England

2030. Falkoff, D., Statistical theory of irreversible processes, Part I. Integral over fluctuation path formulation, *Ann. Phys.* **4**, 3, 325–346, July 1958.

In a thermodynamic system in equilibrium, the extensive quantities contained in a subsystem are subject to fluctuations. The sequence of fluctuations $\alpha_1, \alpha_2, \ldots \alpha_n$ observed in a system at times $t_1 < t_2 < \ldots t_n$ is called a fluctuation path. For stationary Gaussian-Markov processes the distribution of the paths is specified in terms of an absolute and a conditional probability $P(\alpha_i)$ and $P(\alpha_i, t_i | \alpha_{i+1}, t_{i+1})$ which can be expressed in terms of the thermostatic entropy (Einstein) and the dissipation function or irreversible thermodynamics respectively [L. Onsager and S. Machlup, *Phys. Rev.* **91**, p. 1505, 1953]. Author transforms the latter expression into an integral over paths by using Wiener integrals. The procedure is formally analogous to Feynman's space-time approach to quantum mechanics. L. Tisza, USA

2031. Brown, W. B., The thermodynamics of steady conduction-diffusion-reaction states of multicomponent fluid systems, *Trans. Faraday Soc.* **54**, 426, 772–784, June 1958.

Phenomenological theory of irreversible processes involving steady states of a single-phase fluid system of several reacting components subject to constant external forces is extended and generalized. It is shown that, in the immediate vicinity of thermostatic equilibrium, this system may be described by a linear thermodynamic field theory, and that the field equations can be derived from a variation principle. Generality of theory may make it useful for treating biological systems.

Theory is applied to heat conduction through a system containing several reacting components confined between two parallel walls; a dependence of the thermal conductivity on the distance between the walls is predicted. E. L. Knuth, USA

Heat and Mass Transfer

(See also Revs. 1919, 1941, 1948, 2017, 2029, 2031, 2044, 2071, 2090, 2091, 2093)

Book—2032. Mialki, W., Nuclear process engineering, an introduction for engineers [Kernverfahrenstechnik, eine Einführung für Ingenieure], Berlin, Springer-Verlag, 1958, xi + 472 pp.

Book covers essentially the same material as the various textbooks on nuclear engineering which are available in this country. Author feels that the development of the processes and of the equipment required for nuclear power generation is a branch of chemical engineering and the title of the book is intended to stress this opinion. The book contains chapters on the principles of nuclear physics, reactor engineering, materials, protection against radiation, control and measuring equipment, isotrope engineering, heat transfer, and handling of waste. Two chapters will be of special interest to the readers of this magazine. The chapter on reactor engineering develops the energy flux and energy balance equations which are the basis of calculations of the critical size of a reactor and of control problems. The similarity of these equations, which are developed on a macroscopic basis to the equations describing heat conduction and diffusion processes, is striking. Correspondingly, many results have their analogs in the last-mentioned processes. The chapter on heat transfer has the unavoidable shortcoming of a condensed treatment of this field in a single chapter covering 30 pages. It is impossible to treat the principles of heat transfer in this space and the author had to restrict himself to the presentation of formulas for turbulent flow of normal fluids and liquid metals through pipes and ducts.

The book is well organized and written in a clear and easily understandable style. It will, therefore, surely find a large group of interested readers on the European market, especially because of the large efforts which are put into the development of nuclear power in that area. E. R. G. Eckert, USA

2033. Kraus, A. D., The effectiveness of a transistor cap as a heat dissipator, ASME-AIChE Heat Transfer Conf., Chicago, Ill., Aug. 1958, Pap. 58-HT-15, 17 pp.

Equations are derived and results plotted for the "fin efficiencies" of the cylindrical sides and flat top of a transistor cap, when heat flows in at the bottom of the cylinder and is dissipated by convection from the entire external surface. Illustrative example shows significant difference between cap temperatures calculated with and without use of author's results.

P. M. Lang, USA

2034. Wiegand, J. H., Simplified equations for transient heat-conduction to insulated metal slab, *Jet Propulsion* **28**, 7, 486–487 (Tech. Notes), July 1958.

Paper considers the transient temperature variation within a plane composite wall consisting of a slab of metal covered by a sheet of insulation. The heat-transfer characteristics for this type of wall are of interest in rocket technology. The wall is heated through a constant heat-transfer coefficient by a gas at constant temperature. The boundary conditions are not well defined in the paper, and one must look at previous work to find that: (a) initially both the metal and insulation are at the same uniform temperature, (b) only the surface of the insulation is heated and not the metal surface, and (c) the only heat flow to or from the metal is from the insulation. An approximate result is given for the time variation in temperature at the interface of the two materials. Reviewer assumes that it is the interface temperature, since the symbol T_i is not defined, and also wonders if the definition in the Nomenclature for T is in reality that for T_i. The result contains two constants which can be evaluated for given thicknesses and physical properties of the materials. The thermal conductivity of the metal is assumed infinite. R. Siegel, USA

2035. Miranker, W. L., A free boundary value problem for the heat equation, *Quart. Appl. Math.* 16, 2, 121–130, July 1958.

The existence of the following free boundary-value problem for the equation of heat conduction is proved: $u_t = \lambda^2 u_{xx}$; $u_x(0,t) = -G(t) < 0$; $u[R(t),t] = T_c = \text{const}$; $u(x,0) = F(x) \geq T_c$ for $0 \leq x \leq A$ and $u_x[R(t),t] = B - C R_t'(t)$, $B \geq 0$, $C > 0$ consts. Physically the equations describe the phenomena of evaporation, fusion and sublimation, for example. Previous analytical and numerical studies have not discussed existence, which is established here by means of Picard iteration applied to a functional equation approach due to I. Kolodner. Proof of existence is carried out both in the small and in the large. F. V. Pohle, USA

2036. Ruoff, A. L., An alternate solution of Stefan's problem, *Quart. Appl. Math.* **16,** 2, 197–201 (Notes), July 1958.

Author has resolved two classic problems (Stefan, Neumann) for the one-dimensional heat conduction equation with a moving interface due to melting of a solid. In the Stefan problem entire solid is at the melting point and one face is raised above melting temperature. In the Neumann problem a semi-infinite bar is at a temperature below melting temperature and leading edge is instantaneously raised above melting temperature. Both problems are solved by the aid of the substitution $y(x,t) = x/[2(\alpha t)^{1/2}]$ which converts governing parabolic equation in $u(x,t)$ into an ordinary differential equation in $u = u(y)$. F. V. Pohle, USA

2037. Gardon, R., Calculation of temperature distributions in glass plates undergoing heat-treatment, *J. Amer. Ceram. Soc.* **41,** 6, 200–209, June 1958.

A method is presented for calculating temperature distributions in diathermanous (transparent to infrared) sheets that are being heated or cooled. It differs from previous calculations of this type in that it takes a more comprehensive account of radiative effects that play a part in these processes. Principally, these effects are the penetration of external radiation into the sheet, the emission and partial reabsorption of radiation within the sheet, and multiple internal reflection between the surfaces of the sheet. A high-speed digital computer has been programmed to perform these calculations. Qualitative and quantitative results of a few examples are presented to illustrate the influence of diathermancy on the thermal history of clear and opaque glass plates undergoing various heat-treatments. Y. S. Touloukian, USA

2038. Campbell, W. F., One-dimensional transient heat flow in a multilayer slab, *J. Aero. Sci.* **25,** 5, 340–341 (Readers' Forum), May 1958.

Problems on neat conduction in composite media are of considerable theoretical and industrial significance (thermal processes in multilayer walls, aerodynamic heating, etc.). Of course, the pertinent analytic formulas are usually complicated.

Present paper deals with the temperature field in a double-layer slab heated at one end, the other boundary being insulated. Thermal properties of the material are assumed to be independent of temperature. Author gives a quite general solution of the problem, and his interesting results are to be considered as a generalization of former valuable deductions on the subject as given by S. Wassermann [AMR **11** (1958), Rev. 3752].

V. Vodicka, Czechoslovakia

2039. Murray, W. D., and Landis, F., Numerical and machine solutions of transient heat-conduction problems involving melting or freezing, Part I: Method of analysis and sample solutions, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-16, 34 pp.

In generalization of some earlier methods for the calculation of the motion of the freezing front and the temperature distribution in one-dimensional problems involving a change of phase, authors consider (a) the method of expanding (or contracting) lumps (the freezing front is always at the juncture of the same two lumps, one in the liquid phase, the other in the frozen phase), (b) the method of space-fixed lumps, when (A) differentials, (B) differences are taken with respect to time. Interpolation formulas are given for the location of the front in method (b) as it travels through a lump, Δx. Both analog and digital solutions are given for sample problems and their relative merits are discussed. G. Horvay, USA

2040. Popovici, M., Heat-insulating roof elements of prestressed concrete used for industrial buildings (in Rumanian), *Indust. constr. Mater. constr.* **8,** 10, 546–557, Oct. 1957.

Various types of structural members indicated by title are thoroughly described and analyzed on the basis of research performed by author with collaboration of Ion P. Mihai and Gh. Calin in the Institute of Scientific Research in Construction (I.C.S.C., Institut de Cercetari Stiintifice in Constructii). Nine types were investigated experimentally and theoretically: (1) Thin slabs in prestressed concrete with insulating top slab of expanded slag concrete. (2) Thicker slabs of expanded reinforced slag concrete with a row of circular holes; an alternative was tested with a double row of circular holes having smaller diameter. (3) Hollow blocks of various cross sections assembled by typical posttensioning methods with grouted joints. (4) Reinforced-concrete elements, either steam-cured or pretensioned, with air spaces for thermal insulation. (5) Elements of pretensioned light-weight concrete, consisting of 1¼-in. steam-cured edge ribs, with semi-rigid top insulation, ¾ in. thick. (6) Cellular evaporated concrete poured between prestressed-concrete ribs, with thickness equalling the full depth of the ribs. (7) An alternate of type 6; thinner slab of cellular concrete poured partly on top of the ribs. (8) An alternate of type 7; the slab of cellular steam-cured concrete combined with prestressed (pretensioned) concrete ribs. (9) Alternate of type 8, both the light-weight concrete slabs and prestressed ribs being poured monolithically.

Other chapters present the assembly of these elements with long-span beams in prestressed concrete, theoretical analysis of these composite structures, results of testing, and suggestions for further development of these structural schemes. Reference is made to research and publications by other investigators and to official Rumanian specifications for manufacturing precast and prestressed elements of ordinary and cellular concrete, Bucharest, 1956. J. J. Polivka, USA

2041. Regirer, S. A., Diffusion of a vortex layer and heat exchange (in Russian), *Dokladl Akad. Nauk SSSR (N.S.)* **114,** 4, 737–740, 1957 (Translation by Morris D. Friedman, Inc., 67 Reservoir St., Needham Heights, Mass., R-114, 5 pp.).

Solutions of the differential equations for diffusion of a vortex sheet and heat exchange are discussed using a single independent-variable nondimensional group and constant nondimensional parameters. Viscosity, thermal conductivity and specific heat are considered to be functions of temperature. Solutions are given for (1) constant viscosity, thermal conductivity and specific heat, and (2) variable viscosity. Curves for estimating the damping of the temperature and velocity perturbations are presented as functions of Prandtl number. R. G. Nevins, USA

2042. Muller, G. L., Experimental forced convection heat transfer with adiabatic walls and internal heat generation in a liquid metal, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-17, 17 pp.

Circulating mercury was volume heated electrically in a 0.25-in. i d × 18-in. vertical adiabatic glass tube. Wall and mixed mean fluid temperature measurements permitted test of heat-momentum transfer analogy at zero wall thermal flux limit. In Peclet number range of 600–3000 and volumetric heat generation rate 1.4×10^7 to 8.3×10^7 B/hr-ft³, temperature differences were 49% higher than analogy prediction.

Poppendiek's analysis was reworked into integral form to show that internal heat generation decreases Nusselt number for wall heating and increases it for cooling. A. Sesonske, USA

2043. Rosner, D. E., Recent advances in convective heat transfer with dissociation and atom recombination, *Jet Propulsion* **28,** 7, 445–451, July 1958.

Author summarizes progress related to heat transfer in presence of dissociation and recombination processes considering continuum flow in the absence of ionization, surface melting, vaporization, sublimation, on subsurface reactions. He discusses five general

problems:

(1) Effects of gas-phase and surface reaction;

(2) Macroscopic approach to aerothermochemistry;

(3) Energy flux vector—"Effective" thermal conductivity;

(4) Chemical reactions with convection in laminar and turbulent flow;

(5) Required information on thermodynamic and transport properties and on chemical-kinetic parameters related to gas-phase and surface reactions.

Bibliography includes fifty-one papers.

W. F. Davis, USA

2044. Gor'kov, L. P., Stationary convection in a plane liquid layer near the critical heat transfer point, *Soviet Phys.-JETP* **6,** 2, 311–316, Feb. 1958. (Translation of *Zh. Exp. Theor. Phys., Akad. Nauk SSSR* **33,** 402–407, Aug. 1957 by Amer. Inst. Phys., New York, N. Y.)

A theoretical study of heat transfer in a plane liquid layer for downward directed temperature gradients. At certain values of the temperature gradients thermal conduction is replaced by convection, wherein the flow is divided among regular vertical hexagonal prisms. The analysis of the symmetry and amplitude of the motion for the critical gradients requires evaluation of nonlinear equations. The publication presents results for modes of transfer near the critical values. G. A. Hawkins, USA

2045. Hellman, O., A special problem of compressible fluid flow in ducts with friction and heat addition (in English), *Ann. Acad. Scient. Fennicae, Ser. A. I. Math.-Phys.* no. 231, 16 pp., 1957.

Author considers the problem of heat transfer in heat exchanger. Assuming that (1) flow is one-dimensional and uniform over any section of the duct, (2) turbulence is well developed throughout, and (3) heat from hot surface spreads immediately over the whole section, momentum and energy equations combined yield one differential equation for temperature and velocity. In the case of Prandtl number equal to unity, this equation is integrated approximately by iteration. Y. H. Kuo, China

2046. Fastovskii, V. G., and Rovinskii, A. E., Study of heat transfer in a spiral canal (in Russian), *Teploenergetika* **4,** 1, 39–41, Jan. 1957.

2047. Ruban, V. L., Study of the heat transfer from latex to a tube wall (in Russian), Thesis, Leningr. Technol. Inst., Leningrad, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6861.

2048. Gregorig, R., Is a layer of dirt always unfavorable in convective heat transfer? *Escher Wyss News* **29,** 3, 32–35, 1956.

2049. Arajs, S., and Legvold, S., Free-convectional heat transfer from a single horizontal wire, *J. Chem. Phys.* **29,** 4, 697–699, Oct. 1958.

Free-convectional heat transfer from single, horizontal heated, 2-, and 3-mil platinum wires was measured in gaseous A, N_2, O_2, CO_2 and in liquid $(CH_3)_2CO$, CH_3OH, $C_6H_5CH_3$. The measurements, extending approximately from $GrPr = 1$ to $GrPr = 10^{-5}$, satisfied the Senftleben correlation. From authors' summary

2050. Millsaps, K., and Pohlhausen, K., The laminar free-convective heat transfer from the outer surface of a vertical circular cylinder, *J. Aero. Sci.* **25,** 6, 357–360, June 1958.

The title problem for constant surface temperature has recently been treated by E. M. Sparrow and J. L. Gregg [AMR **9** (1956), Rev. 1609] who used an expansion in power series and the Kármán momentum method. Authors give a similarity solution for the particular case that the surface temperature varies linearly with the height of the cylinder. By suitable transformations two ordinary differential equations are obtained and solved numerically. There is also fair agreement with approximate solutions which were obtained from an integral form of the foregoing differential equations with the help of parabolic velocity and temperature distributions within the boundary layer. Solutions are given for Prandtl numbers of 0.733, 1, 10, and 100. H. Schuh, Sweden

2051. Smirnov, A. G., Free heat convection of mercury in closed circular tubes, *Soviet Phys.-Tech. Phys.* **2,** 10, 2209–2215, June 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 6, 2373–2379, Oct. 1957 by Amer. Inst. Phys., Inc. New York, N. Y.)

Heat transfer along a column of mercury contained in a glass tube is studied by measuring the temperature at several places along the column, using embedded thermocouples. A heater mounted at the bottom, and a cooler, a few degrees colder than the room, mounted at the top, permit the variation of the rate of heat flow. Columns vary from 0.56 to 1.34 cm in diameter and 32 to 56 cm in length.

A plot of the excess of mercury temperature over that of the room against distance h from the heater shows that temperature and its gradient decline with increasing h. Three regimes can generally be recognized: near the heater, excess temperature is a sharply declining exponential function of distance (*supercritical*); near the upper end, the relation is also exponential, though with a smaller logarithmic slope (*subcritical*). Between the two exponential regions, excess temperature is a linear function of h (*critical*). For slow heat transfer, all the column may be subcritical; for very fast heat transfer, all of it may be supercritical. As rate of heat transfer increases, the linear region shifts from the heater towards the cooler, but keeping constant in length, and remaining within the same range of excess temperature.

Numerical checks suggest that the critical region satisfies the Rayleigh criterion for laminar convection. For faster heat flow (supercritical Rayleigh numbers), the transfer is by turbulent convection, while in the subcritical region with Rayleigh numbers less than the critical 70 in this experiment, transfer is essentially by molecular conduction. (This latter point is also borne out by observations with the heater placed on the top; here, in the absence of convection, the whole temperature distribution always turns out to be subcritical, and satisfies the equation of heat flow along an uninsulated rigid bar.) The characteristic lengths (or logarithmic slopes) of the two exponential regimes are inferred to be proportional to the square-root of the effective coefficients of heat transfer in the subcritical and supercritical regions.

The above findings are not greatly affected by inclining the tube up to 30° from the vertical, but there is a slight increase in the critical temperature gradient, a reduction in heat transfer for a given temperature pattern, and a warming-up of the supercritical region, compensated by a cooling down of the subcritical one.

While these important findings relate to convection, reviewer feels that this paper is only an indirect approach to the subject of its title. W. Hitschfeld, Canada

2052. Boberg, J. E., and Starrett, P. S., Determination of free convection heat transfer properties of fluids, *Indust. Engng. Chem.* **50,** 5, 807–810, May 1958.

Authors deduce the free convection modulus

$$\Phi = (c_p k^3 \rho^2 \beta g/\mu)^{\frac{1}{4}}$$

from the natural cooling law of a heated little copper sphere $1\frac{1}{2}$ inches in diameter immersed in a beaker of the test fluid. The immersion may induce movements in the fluid and so give some disturbance in the results. C. Codegone, Italy

2053. Chin, J. H., Skirvin, S. C., Hayes, L. E., and Silver, A. H., Adiabatic wall temperature downstream of a single, tangential injection slot, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-107, 8 pp.

Experimental results are presented for single, tangential slot film cooling or film heating of an adiabatic flat plate in a subsonic turbulent flow under zero pressure gradient. The results are correlated in terms of a film effectiveness (defined as the ratio of the temperature difference between initial mainstream and local flat plate to that between initial mainstream and the injected fluid at the slot) which is expressed as a function of the dimensionless distance downstream from the injection slot (reference to slot height), the initial density and velocity ratios between main and injection streams, the injection Reynolds number (based on slot height), and the mainstream Reynolds number (based on upstream hydrodynamic starting length). The data of Wieghardt and of Seban, Chan, and Scesa are expressed in terms of the present correlation variables and compared with the present results.

From authors' summary

Book—2054. Hayes Aircraft Corporation Infrared Radiation Staff, An introduction to the principles of infrared physics, 2nd ed., Birmingham, Ala., Hayes Aircraft Corp., 1957, vii + 74 pp. (Paperbound)

A very brief survey in infrared physics is divided into six chapters: the nature of infrared radiation, enumeration of basic laws (Kirchhoff, Stefan-Boltzmann, Wien, Rayleigh-Jeans and Planck), characteristics of the infrared spectrum, nonblack-body radiation, basic forms of infrared instrumentation, and emissivity characteristics of metal surfaces. The appendices to the book include definitions of infrared terms and a bibliography of generally known books. Much effort has not been made to explain the basic concepts in the text and the explanation of practical importance of infrared physics is entirely omitted. The book is obviously intended for a concise introductory course for the training of new workers in the field of infrared radiation research.

F. Krupka, Czechoslovakia

2055. Dokuchaev, N. F., Thermohygrometric methods for determining vapor concentration in boundary layers (in Russian), *Zh. Tekh. Fiz.* **26,** 10, 2348–2355, Oct. 1956.

Paper describes experimental methods for determining concentration and temperature of vapor in a small volume. Their application for investigation of boundary layer at different conditions of vaporization is shown. Four types of micro-hygrometers and micro-psychrometers were built and tested, with practically error-free pick up of moisture in hygrometer. Optical methods developed by Kolesnikov eliminate the interference of the instrument with the measured phenomenon, but are limited by isothermic conditions. Linear distribution of temperature and vapor concentration were assumed to compare the results with the theory. Investigation of humidity within a porous body was carried out, and in the boundary layer over the surface of water. Two different methods showed good agreement in obtained results. Coefficients of diffusion and Nusselt number agree with the values from other experiments. Two of the designed instruments are valuable for the investigation within small volumes not accessible by other methods.

P. Bielkowicz, USA

2056. Lowdermilk, W. H., Lanzo, C. D., and Siegel, B. L., Investigation of boiling burnout and flow stability for water flowing in tubes, *NACA TN* 4382, 17 pp. + 5 tables + 11 figs., Sept. 1958.

The effects of flow restriction and compressible volume, located ahead of the test section, on flow stability and burnout heat flux were surveyed experimentally with water flowing in tubes. The minimum restriction pressure drop required to stabilize the flow and result in maximum burnout heat fluxes varied nearly linearly from 5 to 100 lb/sq in. with an increase in velocity from 0.5 to 40 fps. A compressible volume located between the restriction and the test section resulted in flow instability and lowered the burnout flux by as much as 80%. Correlations of the data are presented for low- and high-quality burnout regimes.

From authors' summary

2057. Siegmund, F. F., The influence of the direction of the fluid flow on the temperature development in heat exchangers (in Russian), *Trudi Kazansk. Khim.-tekhnol. In-ta* no. 19–20, 384–420, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6854.

2058. Leitner, A., Temperature pattern in the plate shaped matrix of a regenerator (in German), *Radex Rundschau* no. 7, 349–353, Oct. 1956.

2059. Shatzer, W. T., Engineering method for determining a design envelope for air-to-air crossflow heat exchangers, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-12, 23 pp.

A procedure is outlined for determining a "near-optimum" heat-exchanger design envelope. This is made possible by providing (a) limits on the number of heat-exchanger core configurations evaluated, (b) parametric equations which represent the heat-transfer and pressure-loss characteristics of various tubular and plate-fin cores, and (c) by utilizing basic equations which express the relationship between the heat-exchanger heat-transfer requirements and drag imposed on an aircraft.

From author's summary by W. Gumz, Germany

2060. Bressler, R., Cross-flow heat transfer from individual rows of tubes in tube banks having small stagger ratios (in German), *Forsch. Geb. Ing.-Wes.* **24,** 3, 90–113, 1958.

Influence of Reynolds number and stagger ratio on total heat transfer and pressure drop, and on distribution of heat transfer, is investigated for cross flow of air past various combinations of tubes. Reynolds number range was from 5000 to 20,000. An "inlet length" was found extending over the first three to seven rows, after which the heat transfer attained a constant value; varying the stagger ratio affected only the first few rows at lower Reynolds numbers. Results are obtained from a carefully conducted series of tests and will be of considerable value to designers of heat exchangers.

R. N. Cox, England

2061. Lichtenstein, J., A comparison of cross and counterflow cooling towers, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-206, 21 pp.

Both cross- and counterflow cooling towers are employed in practice. It is, therefore, desirable to bring them both on a common basis of calculation to facilitate comparisons in economic evaluations. Paper develops a method which extends the graphic calculations of counterflow towers to the cross flow. It then employs the method to make some comparisons of surface requirements and performance of the two towers, when both are designed for the same set of cooling conditions.

From author's summary

2062. Glaser, H., Simplified calculation of the diffusion of water vapor through walls consisting of several layers, including the effect of water and ice formation (in German), *Kältetechnik* **10,** 11, 358–364, Nov. 1958.

Equations are derived for the vapor pressure and vapor flux in a wall consisting of several layers under the condition of vapor condensation. The equations are valid for the case when the influence of the heat of condensation on the temperature distribution may be neglected. It is shown that at the borders of different layers either additional water vapor condenses or the vicinity is drying out. In a narrow range around 0° C a homogeneous wall stays dry, which is verified by experiments. A numerical example gives an impression of the possible conditions in an insulated wall of a cold store.

From author's summary

2063. Nosyrev, B. A., Actual process of heat exchange in a compressor cylinder (in Russian), *Trudi i. Materialy, Sverdl. Gorn. In-ta* no. 26, 203–216, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5449.

A method is proposed for determining the temperature in the cylinder of a piston compressor at the end of the compression stroke (at the beginning of the ejection stroke). A method is built up for the presentation of a thermal diagram of the actual cycle (in coordinates T-S) in accordance with the data furnished by the indicator-diagram. An example is given of the calculation. No comparison of the calculation data with the experimental is furnished.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2064. Dillon, P. L. P., and Line, L. E., Jr., Heat transfer between solid particles and gas in a rocket nozzle, *Jet Propulsion* **26,** 12, 1091–1097, Dec. 1956.

Combustion

(See also Revs. 2009, 2082)

2065. Schmidt, E., Ignition in the shock tube (in German), *Brennstoff-Wärme-Kraft* **10,** 6, 295–298, June 1958.

Compression in a shock front presents an ideal means for raising the pressure and temperature of the gas to a desired enhanced value, and for observing whether reaction ensues, with or without time delays. Though observation of them is convenient, stationary compression shock fronts require very considerable quantities of gases.

Short-lived compression shocks can however be studied in shock tubes. Diagrams and photographs are given of a shock tube 4 m long and 21 × 30-mm internal cross section constructed by the authors. Schlieren photography is recorded of ignitions in reactive mixtures such as $2H_2 + O_2$. Illustrations are given of delays to ignition, of pre-ignition reactions, and of detonations. Spinning wave fronts are recorded. In Germany it is planned to extend this work to include photography with 25,000 frames per second.

A. R. Ubbelohde, England

2066. Potter, A. E., Jr., and Wong, E. L., Effect of pressure and duct geometry on bluff-body flame stabilization, *NACA TN* 4381, 15 pp. + 1 table + 10 figs., Sept. 1958.

Blow-off velocities and recirculation-zone lengths of propane-air flames stabilized by cylindrical flame holders were measured as a function of pressure (0.25 to 0.8 atm), fuel-air ratio, cylinder diameter (3/8 to 1.0 in.), and tunnel geometry (3 by 3 and 1 by 3 in.) for Reynolds numbers ranging from 0.64×10^4 to 17.3×10^4. The variation of blow-off velocity with flame holder size and tunnel geometry was principally caused by variation of recirculation-zone length. The variation of blow-off velocity with pressure was principally caused by variation of the critical time (ratio of recirculation-zone length to blow-off velocity) with pressure. From authors' summary

2067. Freeman, N. C., Dynamics of a dissociating gas. III. Non-equilibrium theory, *AGARD Publications, Rep.* 133, 21 pp., July 1957.

The theory of equilibrium and quasi-equilibrium dissociation of an ideal gas constitutes parts I and II of this trilogy. Part III extends the theory to nonequilibrium conditions. The extension includes the equilibrium parameters of the theory presented in the first two parts plus an additional nonequilibrium parameter which establishes the time scale of the dissociation phenomena. It is assumed that the vibrational and rotational degrees of freedom are completely excited and the Rankine-Hugoniot shock-wave relations are employed for an infinitesimally thin region before dissociation begins. The changes in the pertinent thermodynamic properties downstream of this region are found by application of an extension of the Newtonian theory of hypersonic inviscid flow. Paper does not offer quantitative values of the nonequilibrium parameter but significant and observable changes from the undissociated values are clearly indicated. J. F. Lee, USA

2068. Broadwell, J. E., and Sellars, J. R., Solution of laminar flame problems by use of the analog computer, *WADC TR* 56-290 (PB 121711; ASTIA AD 110477), 33 pp., June 1956.

Paper is an excellent example of the use of an analog computer in scientific work. Flame speeds and eigenvalue for the boundary conditions are calculated for the decomposition of hydrazine and ozone. Results are compared with previous work over a range of diffusion parameters. Agreement is roughly within 10% for von Karman and Penners work and somewhat closer to the values of Hirschfelder, Curtiss and Campbell.

The conditions at the "cold boundary" are discussed from a viewpoint that takes into account the initial flame development. This leads to a clearer choice of proper boundary conditions.

J. H. Davidson, USA

2069. Plyer, E. K., and Tidwell, E. D., Infrared emission spectra of flames under high resolution, *J. Res., Nat. Bur. Stands.* **61,** 4, 263–268, Oct. 1958.

The spectrum of a hydrogen-oxygen flame and an oxyacetylene flame has been measured in the near infrared region with a high-resolution grating spectrometer. In the region from 3.7 to 4.1 μ many lines are observed which have not been classified. They may arise from transitions to the ν_2 or ν_3 bands of water vapor. The intensity of the first overtone band of CO was increased when a high-frequency discharge was passed through the flame, and the infrared CN band was increased in intensity when N_2O was mixed with the acetylene. The results are shown in five figures of the observed spectra. From authors' summary

2070. Curtis, R. W., and Johnson, L. E., Use of flow models for boiler-furnace design, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-120, 7 pp.

This paper discusses, from a practical viewpoint, the use of scale models to study flow-distribution problems encountered in the design of boiler furnaces. Some of the types of models used by the authors' company and the methods of testing each type are described. A brief discussion of model design is presented. An example of how flow models were used to aid in the design of the furnace arrangement for a specific unit is described.

From authors' summary

2071. McManus, H. N., Jr., Ibele, W. E., and Murphy, T. E., The effect of fuel types and admission method upon combustion efficiency, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-128, 4 pp.

A series of tests to determine the effect of combustion-chamber length for three different types of fuel admission (gaseous, spray, and vaporized) upon combustion efficiency was performed in identical combustor geometries and with similar air-flow patterns. The effects of fuel-air ratio and full-section velocity were examined for individual methods of admission. The effect of fuel volatility also was examined. It was found that the vaporized-fuel type of admission was superior in efficiency to the spray-fuel admission in all comparable cases. Increased fuel volatility improved performance in the case of the vaporizer but did not affect the performance of the spray nozzle. The performance of vaporizing tubes was found to vary inversely with size. An optimum size was exhibited. From authors' summary

Prime Movers and Propulsion Devices

(See also Revs. 1890, 1912, 1989, 2023, 2078, 2114)

2072. Concordia, C., Effect of steam-turbine reheat on speed-governor performance, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-36, 5 pp.

Paper shows the effect of the frequency stability and response of an electric power system using steam-turbine reheat. It is shown that, in general, reheat tends to decrease the damping of the frequency variations of the system as a whole, to increase the damping of tie-line power oscillations, and to increase the maximum frequency deviation occasioned by an abrupt load change. The system responses were determined by means of an analog computer. From author's summary

2073. Rosecky, E. J., and Gibeling, A. H., A condensate flow-measuring section for steam-turbine performance testing, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-206, 5 pp.

2074. Lubick, R. J., and Wallner, L. E., Stall prediction in gas-turbine engines, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-133, 7 pp.

From a study of multistage compressors operating in gas-turbine engines the sequence of events which occur during the stall process was determined. By using this information and stage-characteristic curves, it is shown that the compressor stall limit may be computed for any disturbance.

From authors' summary

2075. Sutherland, R. A., Free discharge through a turbine distributer, case, and draft tube, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-76, 3 pp.

The experience of discharging water freely through the turbine without the runner at the Pelton Hydro-Electric Development in Oregon is described, and an indication of the discharge coefficient is given. From author's summary

2076. Gasparovic, N., Pressure ratio and economics of gas turbines (in German), *Brennstoff-Wärme-Kraft* **10,** 5, 223–224, May 1958.

2077. Gasparovic, N., Air turbine with reduced pressure (in German), *Forsch. Geb. Ing.-Wes.* **24,** 3, 79–89, 1958.

Author presents thermodynamic analysis of gas turbine cycles, in which the combustor is located behind the turbine. Air entering the turbine is heated by combustion products in a heat exchanger. The combustor is a "Schmidt Tube" in which, as in the V1, pulsating combustion takes place with increase in pressure. Author suggests that such systems are of interest as they permit higher turbine inlet temperatures.

Simplest system analyzed consists of a heat exchanger, a turbine, and a Schmidt tube. In more efficient system, air is compressed in a turbine-driven compressor before entering the heat exchanger.

Two systems of this general type, in which steam cycles are coupled with the air cycles, are also investigated.

Analysis is based on hypothetical component performance under steady-state conditions. R. P. Kroon, USA

2078. Cherkasov, B. A., and Emin, O. N., Analytical calculations of the characteristics of a gas turbine, taking into account the power loss through scavenging of a given degree through flat screens (in Russian), *Trudi Mosk. Aviats. In-ta* no. 68, 5–41, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7756.

Calculations are put forward for the features of an elementary stage of a gas turbine carried out on the mean diameter for cases of trans- and supercritical regions in the working wheel. In the calculations consideration is given to loss changes due to scavenging of flat screens to a given degree and to the influence of Reynolds number on the losses in the jet apparatus and the working wheel. In the execution of the calculations wide use is made of gas dynamic functions. An example is given for the calculation of the features of a model gas turbine. V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2079. Bragg, S. L., and Ratcliffe, H., Characteristic velocity as a measure of available work, *Jet Propulsion* **28,** 11, 762–764 (Tech. Notes), Nov. 1958.

The purpose of this note is to demonstrate that the power available from a gas turbine is dependent primarily on the characteristic velocity of the entering gas, and is otherwise insensitive to gas properties, such as the specific heat ratio.

From authors' summary

Book—2080. Barrere, M., Jaumotte, A., Fraeijs de Veubeke, B., and Vandenkerckhove, J., Propulsion by rockets [La propulsion par fusées], Paris, Dunod, 1957, xi + 389 pp. (Paperbound)

A broad review of the problems of liquid and solid propellant rockets includes a discussion of test facilities and external ballistics. The twelve major divisions are: (1) Energy properties of rocket propulsion, (2) Propulsion nozzles and characteristic parameters of rocket motors, (3) General discussion of the solid-propellant rocket, (4) Solid-propellant rockets with any combustion surface, (5) General study of liquid-propellant rockets, (6) Liquid propellants, (7) Experimental techniques in rocket propulsion, (8) Low-frequency combustion instability in liquid-propellant rockets, (9) Study of high-frequency instabilities, (10) External ballistics of unguided engines, (11) Principles of guidance with transverse accelerations, (12) Optimum trajectories.

Theoretical and working equations are presented as well as qualitative descriptions of rocket engine behavior. Numerical examples illustrate the equations.

This is a useful textbook for the rocket engineer who can read French, and does not duplicate existing texts in English.

M. Gerstein, USA

2081. Newton, R. R., On the optimization of physical propulsion systems, *Jet Propulsion* **28,** 11, 752–753 (Tech. Notes), Nov. 1958.

Regarding the exhaust velocity c as a free parameter and neglecting gravity, the ratio of c to v, rocket velocity, is derived to give maximum efficiency. A similar ratio for single-stage motors which require minimum power in climbing against gravity is also derived. The mass ratio $M = 4.9214$ for both cases and c is proportional to the desired v. The value of c for the minimum power in climb is twice that for the maximum efficiency and the efficiency is one-fourth of the maximum.

From author's summary by A. N. Petroff, USA

2082. Priem, R. J., Propellant vaporization as a criterion for rocket-engine design; Calculations of chamber length to vaporize various propellants, *NACA TN* 3883, 15 pp. + 1 table + 3 figs., Sept. 1958.

Vaporization rates were calculated for drops of *n*-heptane, ammonia, hydrazine, oxygen, and fluorine. The present propellant vaporized is correlated with an effective chamber length for various spray conditions, and various engine-design and operating parameters. The results show that the effective chamber length required to vaporize a given high percentage of propellant is the shortest with oxygen and increases for fluorine, heptane, ammonia, and hydrazine in that order. From author's summary

2083. Dunlap, K., Erehm, R. L., and Nicholls, J. A., A preliminary study of the application of steady-state detonative combustion to a reaction engine, *Jet Propulsion* **28,** 7, 451-456, July 1958.

Steady-state performance characteristics have been calculated for a supersonic detonative combustion ram engine. Authors assume supersonic diffuser entrance with fuel injection at minimum area section followed by expansion section containing simple streamlined insert to stabilize oblique detonation wave. Analysis also contains an assumed effective ignition temperature of 2000R below which the fuel-air mixture must be kept prior to passing the oblique detonation wave. Authors point out that the results are quite sensitive to the value of this assumed ignition temperature. Calculations include specific thrust and specific fuel consumption for hydrogen and acetylene. Engine produces no thrust below about Mach 4.5 and maximum thrust is about 90 lbs per lb of air per second for either fuel, and specific fuel consumption is about 1 lb hydrogen or 3 lbs acetylene per hour per lb thrust.

R. A. Strehlow, USA

2084. Haite, W. F., Propellant explosives classification and the effect on field handling of missiles, *Jet Propulsion* **28,** 7, 489-491 (Tech. Notes), July 1958.

2085. Babkin, Ya. L., A steamjet starting ejector. (Steam jet pump) (in Russian), *Sakharnaya prom-st.* no. 2, 28-30, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 359.

A description is given of a steam jet ejector, designed for creating low pressure (vacuum) in a gas works at the time of starting the work's TETs (Heat electric center) with powerful steam boiler assemblies; an account is given of the sequence of events of starting TETs when using the ejector. A feature of the adopted multijet ejector appears to be the rectangular shape of the diffuser and the mixing chambers, simplifying manufacture and grouping, and not leading, as experiments had shown, to a significant lowering of efficiency.

V. M. Akimov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2086. Pedersen, G. H., Aerodynamic development of a turbojet engine, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-127, 8 pp.

2087. Lutz, O., On gas dynamic mixing phenomena and thrust increase through jet mixing (in German), *Brennstoff-Wärme-Kraft* **10,** 6, p. 299, June 1958.

Paper supplements an earlier publication by the author in the year book for 1955 of the *Wiss. Gesellschaft Luftfahrt.*

Gas dynamic mixing is treated by graphical computational methods to survey both the subsonic and supersonic regions. Author discusses the mixture gap which arises when two gas streams mix in a cylindrical region, and the impulse and energy theorems cannot be reconciled.

A full account is due to appear in the year book for 1957 of the *Wissenschaftliche Gesellschaft für Luftfahrt.*

A. R. Ubbelohde, England

2088. Bussard, R. W., Concepts for future nuclear rocket propulsion, *Jet Propulsion* **28,** 4, 223-227, Apr. 1958.

Looking beyond the "conventional" methods of nuclear rocket propulsion involving solid-phase conduction and convective transfer of fission heat to a working fluid, author briefly considers the feasibility of exploiting the energy released by fusion, by radioisotope decay, and by fission within (or immediately adjacent to) the gas phase. It is concluded that (1) detailed speculations concerning thermonuclear propulsion should be deferred until controlled release of fusion has been demonstrated; (2) the rates of specific power output available from radioactive decay are not great enough for rocket applications; and (3) the performance advantages inherent in use of a gas-phase fission process are great enough to warrant serious study of the problem of separation of the fissionable fuel species from the diluent propellant species. Also examined are schemes in which power generated by a conventional (turbine-compressor) reactor circuit is transferred to a working fluid either by a series of positive-displacement mechanical compression steps or by an electrical discharge. The performance of these schemes is found to be limited by the weight of the power conversion equipment, particularly of the components in the reactor circuit, and it is concluded that the efficient exploitation of nuclear energy for space-vehicle propulsion requires elimination of the intermediate mechanical conversion step.

L. Green, Jr., USA

Magneto-fluid-dynamics

(See also Rev. 1801)

Book—2089. Kampe de Feriet, J., Ferrari, C., and Agostinelli, C., Course on turbulence theory, Vol. 1 [Corso sulla Teoria della Turbolenza, Vol. Primo], Torino, Libreria Editrice Universitaria Levrotto & Bella, 1957, viii + 339 pp. (Paperbound)

This volume presents the text of a special course (or rather a symposium) on turbulence held in Varenna, Italy during Sept. 1957. There are three monographs by the principal authors and five short papers by other contributors. The first monograph is by J. Kampe de Feriet (in French) entitled "Mathematical problems in the theory of homogeneous turbulence." It contains a lucid exposition of the early history of turbulence theory, bringing into focus the mathematical difficulties involving averaging processes. The possible solutions of the Navier-Stokes equation are discussed, especially from the point of view of analog behavior with the linear heat equation. After discussing the simplified "model equation" of Burgers and also Hopf's problem, author embarks on the discussion of the Reynolds stresses. The last two chapters deal with statistical mechanics and the statistical treatment of homogeneous turbulence. The entire monograph is written from the mathematician's point of view and it can be of great help to students of mathematics who may want to know what kind of mathematical difficulties arise in the existing theories of turbulence. An excellent bibliography completes this work.

The second monograph is written by Carlo Ferrari and is entitled "Wall turbulence" (in Italian). Turbulent shear flows that have solid boundaries are the subjects of this monograph. In the first chapter the Reynolds equation and the turbulent energy equation are introduced with sufficient detail to help the uninitiated to familiarize himself with the concepts. The second chapter contains discussion of shear flows in general and turbulent channel flow in particular.

The third chapter deals with the turbulent boundary layer on a flat plate in the absence of a pressure gradient and in the fourth chapter turbulent boundary layer with pressure gradient is discussed. There is a final chapter that is more of an appendix that discusses some recent findings of Mattioli, Burgers and Malkus. Author presents the many aspects of turbulent shear flow in great detail. He has undoubtedly intended it for a textbook and it fulfills this scope well. He uses experimental results rather profusely to illustrate theoretical points.

The third is the shortest of the three monographs. It is by Cataldo Agostinelli and it bears the title "Turbulence in magnetohydrodynamics" (in Italian). Author derives the magnetohydrodynamical equations for incompressible fluid with constant viscosity, electric and magnetic properties. He derives the governing equations for the correlation functions that, besides the familiar ones, also include the correlations between velocity and electromagnetic field as well as between velocity and pressure.

Author also offers some conjectures for the spontaneous generation of electromagnetic fields in turbulent fluid.

The short papers are by M. L. Dubreil-Jacotin on the "Axioms of averaging" (in French); by Jean Abault on "Reynolds transformation on a finite ensemble" (in French). Both of these papers deal with extensions of Kampe de Feriet's findings. Oddvar Bjørgum gives a note entitled "On the possibility of a mathematical theory of shear flow turbulence (in English). John Laufer has an expository paper, "The hot-wire technique in supersonic research" and, finally, a somewhat longer contribution by R. Wille and O. Wehrmann, "Hot-wire measurements in free shear layers" (in German). This one deals with hot-wire measurements on a split-up Karman vortex street. It is essentially the same work as AMR **11** (1958), Rev. 2276. L. S. G. Kovasznay, USA

2090. Kubo, R., Statistical-mechanical theory of irreversible processes. I. General theory and simple applications to magnetic and conduction problems, *J. Phys. Soc. Japan* **12,** 6, 570–586, June 1957.

The principles and formalism of quantum statistical mechanics are reviewed and extended to include fluctuation-dissipation phenomena. Thus the gap between the equilibrium theory or statistical mechanics and the nonequilibrium theory of fluctuations is bridged. A rigorous and elegant explanation of the Onsager symmetry rules, a generalization of the Einstein relations connecting conductivity or mobility with a diffusion constant and illustrations by simple examples of magnetic and conduction problems are presented. J. F. Lee, USA

2091. Kubo, R., Yokota, M., and Nakajima, S., Statistical-mechanical theory of irreversible processes. II. Response to thermal disturbance, *J. Phys. Soc. Japan* **12,** 11, 1203–1211, Nov. 1957.

The general quantum mechanical and fluctuation-dissipation concepts presented in part I of this paper [see preceding review] are tested to yield rigorous relations for kinetic coefficients, such as thermal conductivity, the diffusion constant, thermoelectric power, which can be expressed in terms of generalized forces. A rigorous basis for the Onsager relationships is established and the theory is illustrated by an example from electronic transport phenomena. J. F. Lee, USA

2092. Rossow, V. J., Boundary-layer stability diagrams for electrically conducting fluids in the presence of a magnetic field, *NACA TN* 4282, 23 pp. + 4 tables + 4 figs., Aug. 1958.

Neutral stability curves pertaining to a two-dimensional infinitesimal sinusoidal disturbance are presented for the laminar flow of an incompressible, electrically conducting fluid over a semi-infinite flat plate in presence of either a coplanar or transverse magnetic field. It is seen from the results that the flow is stabilized by either a coplanar magnetic field or by transverse magnetic field fixed relative to the fluid; but a transverse magnetic field fixed relative to the plate is generally destabilizing. Tables, diagrams and bibliography complete the paper.

G. Sestini, Italy

2093. Berger, J. M., Bernstein, I. B., Frieman, E. A., and Kulsrud, R. M., On the ionization and ohmic heating of a helium plasma, *Phys. Fluids* **1,** 4, 297–300, July–Aug. 1958.

A method for ionizing and heating helium plasmas in various stellarator configurations consists of inducing a near-constant electric field along the principal axis of the confining magnetic field. Assuming (1) the gas is 10% ionized at a temperature of a few electron-volts, (2) Maxwellian velocity distributions for the particles, and (3) a negligible charged particle loss across the magnetic field, the pertinent calculations and results are presented. In view of the assumptions the results are not precise but represent an interesting first-approximation.

J. F. Lee, USA

2094. Chuan, R. L., Plasma heating of supersonic airstream, *Phys. Fluids* **1,** 5, p. 452 (Letters to the Editor), Sept.–Oct. 1958.

2095. Syrovatskii, S. I., Contribution to the theory of disruption in magnetohydrodynamics (in Russian), Avtorefer. Diss. Kand. Fiz.-matem. Nauk, Fiz. In-ta Im. P. N. Lebedev, Akad. Nauk SSSR, Moscow, 1954; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7845.

2096. Lehnert, B., An experiment on axisymmetric flow of liquid sodium in a magnetic field, *Arkiv för Fysik* **13,** 10, 109–116, Oct. 1957.

An axisymmetric motion has been generated by a rotating disk in a cylindrical vessel containing 58 litres of liquid sodium and placed in an external magnetic field. Measurements of the internally induced magnetic fields indicate the existence of a toroidal component which circulates around the axis of symmetry and a poloidal component which is restricted to planes through the same axis. The results agree with the elementary theory, as far as orders of magnitude are concerned.

There has been observed neither a formation of instabilities in the twisted field, nor an operation as a self-exciting dynamo; the velocities in the experiment are too small and the degree of asymmetry too low to produce such phenomena.

T. P. Torda, USA

Aeroelasticity

(See also Rev. 2007)

2097. Kussner, H. G., Contribution to the boundary-value problem of elliptical wings (in German), *Z. Flugwiss.* **5,** 2, 50–56, Feb. 1957.

Paper starts with short discussion of Lamé potential functions. Then an expression for the regular velocity potential for a vibrating elliptic disk in incompressible flow is derived in a series of products of Lamé functions. An expression for the singular potential, which must be added in order to represent the singularity at the leading edge, is proposed in the form of an infinite series, with coefficients which are undetermined. This singular potential behaves at the leading edge as $1/s^{1/2}$ (s = distance from point on the ellipse to leading edge) and is finite at the trailing edge. Paper gives an integral representation for the pressure distribution along the ellipse. Author's hypothesis that the kernel of this integral representation is a "difference kernel," i.e. a function of $x - x^1$, $y - y^1$, $z - z^1$, where x, y, z, are Cartesian coordinates, is not clear to reviewer. Using this hypothesis author derives an expression for the singular potential which, however, is too complicated for numerical computation. Using some additional simplifications author derives approximate expressions which have, for a circular plate, deviations of $+2\%$ to -11% from values calculated by others. R. Timman, Holland

2098. Fingado, H., and Taylor, A. S., An approximate method of estimating the effect of elastic deformability of the aircraft structure on the manoeuvre point. I and II, *Aero. Res. Counc. Lond. Rep. Mem.* 3019, 93 pp. + 26 figs., 1957.

Problem is to predict the change of maneuver point, principally due to elastic wash-out (wing torsion and bending, and the effect of fuselage interference), elastic camber, the direct effect of fuselage bending, torsion of the tailplane, deformability of the fuselage-tail-plane attachment, and the direct effect of wing bending on pitching moment. As shown, elastic wash-out of swept wings can result in large changes of maneuver point.

Authors have simplified the procedure by considering directly the effect of deformability on the pitching moment and by introducing representative values for the stiffnesses. The final equation involves only dynamic pressure and certain construction

parameters which are functions of airplane geometry, wing structural layout and limiting design conditions. To maintain simplicity the method is restricted to constant chord wings and uniform spanwise lift distribution.

The derivations of the formulas of the method are lengthy (witness report length in pages); however the application is rapid and simple. Routine procedures, tables, and charts are presented for the reader interested in the direct numerical application of the method. J. DeYoung, USA

2099. Jones, W. P., Oscillating wings in compressible subsonic flow, *Aero. Res. Counc. Lond. Rep. Mem.* 2855, 16 pp. + 4 figs., 1957.

The problem of estimating flutter and stability derivatives for wings of finite span describing simple harmonic oscillations in compressible flow is considered. It is shown that the problem can be reduced to a similar one for an equivalent wing in incompressible flow. The lateral dimensions of the wing are $\sqrt{1-M^2}$ times those of the original wing, and the frequency of oscillation is increased by the factor $(1-M^2)^{-1}$ where M denotes the Mach number of the compressible flow. The mode of oscillation is different but related to that of the original wing. It is suggested that sufficient accuracy might be obtained by representing the boundary condition to first-order accuracy in the frequency and then solving quite generally the integral equation for the velocity potential. Comparisons indicate that this procedure is reasonably satisfactory in the two-dimensional case. For $M = 0.7$, the values of the derivatives show fair agreement with "exact" results over a wide range of frequency parameter values. Since flutter derivatives for wings of finite span are not usually very sensitive to variations in frequency parameter, the calculation scheme should be sufficiently accurate for practical purposes when the combined effects of thickness and viscosity are negligible. It does, however, require a reliable method for calculating derivatives for low-aspect-ratio wings in incompressible flow.

From author's summary by H. Ashley, USA

2100. Samsonov, Yu. A., The vibration of turbine blades under nonlinear frictional forces (in Russian), *Sudostroyeniye* no. 2, 5–7, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6479.

An approximate formula is derived for determining the resonance amplitude of vibration of a turbine blade of ordinary section on the condition that the drag coefficient is proportional to the absolute value of the axial deflection of the blade from the equilibrium position. A comparison with the linear case is made. A graphical method is demonstrated for constructing the curve of amplitudes of vibration in the more complex cases, provided the experimental relationship between the damping decrement of the vibration and the elastic stresses is known. L. A. Rozenberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Aeronautics

2101. Cannon, R. H., and Chandler, D. P., Stable platforms for high-performance aircraft, *Aero. Engng. Rev.* **16,** 12, 42–47, Dec. 1957.

2102. Kuchemann, D., Some ways of obtaining an integrated aircraft, *J. Helicop. Assn.* **12,** 3, 121–140, June 1958.

2103. Jex, H. R., Duration of a constant-mass aircraft with a given airframe weight and arbitrary energy-source weight, *J. Aero/Space Sci.* **25,** 8, 525–526 (Readers' Forum), Aug. 1958.

2104. Schnitzer, E., Experimental evaluation of low-band-pass landing-gear shock absorber for pulse loadings, *NACA TN* 4387, 23 pp. + 2 tables + 10 figs., Sept. 1958.

An experimental evaluation of the load-reducing capabilities of the low-band-pass shock strut was made by comparison with a fixed-orifice shock strut. An experimental low-band-pass strut was constructed and equipped with a high-pressure wheel and tire. Taxi runs were made over single and multiple bumps to determine strut pulse rate response and recycling characteristics. Comparisons for single rapidly applied pulses showed low-pass loads to be 50% of the fixed-orifice strut loads and less than 25% of the fixed-orifice strut loads for repeated bumps. Smaller reductions were shown for rapidly applied pulses superposed on slowly applied pulses during landings on bumps. A low-pass vibration absorber is also described. From author's summary

2105. Harrin, E. N., Low tire friction and cornering forces on a wet surface, *NACA TN* 4406, 10 pp. + 17 figs., Sept. 1958.

An investigation was made by the National Advisory Committee for Aeronautics to study typical tire behavior on wet runways. A specially constructed tire treadmill served as a tire test vehicle whereas force measurements were made by means of a strain-gage balance. Values of maximum braking, full-skid braking, and rolling friction coefficients were obtained at yaw angles of 0° and 4° while operating two tire types (smooth and diamond treaded) in water depths from 0.02 to 0.09 inch and at speeds up to 94 fps including tire planing. Cornering-force coefficients were measured at the free-roll and maximum braking conditions.

From author's summary

2106. McCloud, J. L., III, and McCullough, G. B., Wind-tunnel tests of a full-scale helicopter rotor with symmetrical and with cambered blade sections at advance ratios from 0.3 to 0.4, *NACA TN* 4367, 12 pp. + 1 table + 13 figs., Sept. 1958.

It was found that both rotor torque and blade pitching-moment characteristics provided readily discernible indications of blade stall. Comparison of the stall boundaries showed that the lifting capacity at forward speed of the rotor with cambered blade sections was about 15% greater, or that, at constant lift, the forward speed capability of the rotor with cambered blade sections was 20 to 25% greater than for the rotor with symmetrical blade sections. From authors' summary

2107. Yeates, J. E., Flight measurements of the vibration experienced by a tandem helicopter in transition, vortex-ring state, landing approach, and yawed flight, *NACA TN* 4409, 9 pp. + 11 figs., Sept. 1958.

Some results of vibration measurements during transition near the ground are presented, and the change in magnitude of the vibration with increasing rotor speed is shown. In addition, the pulsative nature of the vibration during vortex-ring state and the reduction in vibration with increasing yaw angle are discussed.

From author's summary

2108. Hooper, M. S., On the wind tunnel testing of helicopter models, *J. Helicop. Assn.* **12,** 3, 91–120, June 1958.

Astronautics

2109. Bryson, A. E., Jr., and Ross, S. E., Optimum rocket trajectories with aerodynamic drag, *Jet Propulsion* **28,** 7, 465–469, July 1958.

Assuming two points in a vertical plane, the initial rocket velocity, and the final mass, authors determine the trajectory which minimizes the initial mass. The three phases: instantaneous boost, sustained burning, zero thrust, are solved using calculus of

variations, with the constraint that the rocket mass can never increase. Variation of density with altitude is assumed exponential, the quadratic drag law is applied, and a calculation is carried out with the Harvard Univac. Numerical example is for the inverse problem, maximum range at various altitudes with a given mass ratio of 2, for a short-range ground-to-air rocket. In addition to other curves, 5 optimum trajectories are plotted; the envelope of the altitude-range curves gives the maximum distance with the optimum thrust programming, i.e., with least fuel. The best initial angle for maximum range ground-to-ground is about 68°, well above the 45° for no drag. G. R. Graetzer, USA

2110. Hall, H. H., and Zambelli, E. D., On the optimization of multistage rockets, *Jet Propulsion* **28,** 7, 463–465, July 1958.

Summary states: "The optimum weight distribution for multistage rockets having different specific impulses and structural factors in each stage is derived. Minimization of gross weight for a given required burnout velocity and payload is the criterion of optimization used. A method is suggested for including in first approximation the effects of gravity, drag and turn."

Reviewer agrees with authors' words "....this method is not a substitute for accurate calculations with a high-speed digital computer. Instead, it has proved to be a valuable auxiliary ....." F. G. Blight, South Australia

2111. Miele, A., Stationary conditions for problems involving time associated with vertical rocket trajectories, *J. Aero/Space Sci.* **25,** 7, 467–469 (Readers' Forum), July 1958.

2112. Ten Dyke, R. P., Computation of rocket step weights to minimize initial gross weight, *Jet Propulsion* **28,** 5, 338–340, May 1958.

Author presents an approximate procedure for hand calculation of optimum rocket step weights in a multi-stage model. A step is defined as a booster segment and when that booster is removed, the remaining hardware is called rocket $i + 1$. At launching of a 3-step model, the entire vehicle is called rocket 1; after the first booster falls away (step 1) the remaining hardware is called rocket 2.

The procedure makes use of certain dynamic programming techniques which permit the engineer to use structure factors that are nonanalytic with discontinuties. The technique leads to recurrence relationships of the type found in allocation problems which may be hand calculated if the model has three or less steps. The equations which are developed lead to a dynamic programming problem in the variables v and N which are, respectively, the velocity ideally added during a stage and the ratio of initial thrust to the weight of the rocket of step i. Values of N may be assigned by certain design conditions. In particular, if N is held fixed, the problem is reduced to only one variable, v.

The procedure presented by the author will enable an engineer to make hand calculations for trial designs, particularly where the number of steps is 2 or 1, and where it is possible to simply describe the initial gross weight of a step as a function of both, the velocity ideally to be added during the time that the booster is active, and the initial gross weight of the available rocket during the same time interval. Where these conditions are not met, recourse may be had to computers.

Reviewer believes that the method will have some applications but that it will be essentially limited in use. The ever increasing use of high-speed electronic digital computing machines will favor more exact methods. Such methods will be programmed in generality once and will then be available for all design work. Even if the procedure proposed by the author is used, the calculations become quite formidable for three or more steps and a digital computer will need to be used.

J. W. Fischbach, USA

2113. Perkins, F. M., An analytical solution for flight time of satellites in eccentric and circular orbits (in English), *Astronaut. Acta* **4,** 2, 113–134, 1958.

A deep and exhaustive study of the perturbations of the radius vector of the circular and elliptic orbits of artificial satellites by atmospheric resistance.

The calculus is based on two pressure laws: $\rho \sim e^{my}$; $\rho \sim y^{\beta}$ where y is height above earth level; ρ atmospheric density; m and β negative constants. The comparisons made between the analytical calculations and the integrations of the movement equation with the calculating machine is excellent.

The profusion of graphics and the illustrative example are of great interest, especially when reckoning the falling time, known initial conditions, and the aerodynamics of the satellite.

The polar flatness of the earth is dispensed with.

F. R. Marsicano, Argentina

2114. Miele, A., and Cavoti, C. R., Optimum thrust programming along arbitrarily inclined rectilinear paths; General variational theory of the flight paths of rocket-powered aircraft, missiles, and satellite carriers, Purdue Univ., School of Aero. Engng., Rep. A-57-8 (ASTIA AD 148 088, 19 pp. + 6 figs.), Dec. 1957; Rep. A-58-2 (ASTIA AD 154 148, 68 pp.), Jan. 1958.

These two papers are reviewed in reverse order as compared to date of publication, since first paper listed presents the more complete and generalized development of basic theory. Both reports deal with application of calculus of variation methods to problem of optimization of flight paths for rocket-propelled air and space vehicles. In this respect they are extensions of work previously published by these and associated authors [see AMR **11** (1958), Revs. 3887 and 4273].

Problem is reduced to three degrees of freedom involving variations with time of lift force, thrust magnitude and thrust direction. General equations of motion are developed and mathematical details of optimization of arbitrary functions are then presented. Engine performance is represented in terms of an arbitrary parameter which is a function of mass flow. In first paper, applications to vertical, horizontal and inclined flight paths are given, as well as special cases such as non-lifting or ballistic missiles. Second paper deals only with rectilinear inclined flight path and with detailed nature of engine performance variation. The optimized function may represent such quantities as range, altitude, velocity and other characteristics of the flight path. M. J. Thompson, USA

2115. Semenov, M. V., Investigation of the motion of satellites of planetary mechanisms (in Russian), *Trudī Seminara po Teorii Mashin i Mekhanizmov In-ta Mashinoved Akad. Nauk SSSR* **15,** 60, 5–27, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5230.

Curves are examined describing, by means of various points, the satellites of planetary passages. A description is given of methods of construction of these curves and of hodographs of velocity and acceleration. It is shown that the satellite curve of an arbitrary three-link planetary mechanism with external or internal lines of contact can be reproduced with a single four-link mechanism (with a double satellite). It is indicated that it is possible to apply satellite curves for different types of directing mechanisms and of interrupted action; as for example, in machines for shaping work. V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2116. Miele, A., Some recent advances in the mechanics of terrestrial flight, *Jet Propulsion* **28,** 9, 581–587, Sept. 1958.

A general survey is presented of the problems of the mechanics of terrestrial flight, with particular regard to the optimization of the trajectories of both quasi-steady and nonsteady flight.

From author's summary

2117. Simons, D. G., Observations made during Manhigh II flight, *Jet Propulsion* **28,** 8 (part I), 521–522, Aug. 1958.

The manned ascent to the 100,000-ft region for 32 hours, launched on Aug. 19, 1957, opened a new realm of research. This flight provided invaluable experience and data on the practical problems of establishing a sealed cabin atmosphere and the effects of isolation and heavy primary cosmic rays on a human subject. Observations included evaluation of the balloon-capsule system performance, meteorological, astronomical and medical studies. From author's summary

2118. Winzen, O. C., and Parks, O. P., Operation Manhigh II, *Jet Propulsion* **28,** 8 (part I), 523–532, Aug. 1958.

The Manhigh II flight pointed out the value of the balloon-capsule technique in the development of the manned space cabin, and studied the human factors in a space equivalent environment. The first day and night flight of its kind, it set a new world altitude record. This paper includes a description of the balloon and capsule system and the flight operation.

From authors' summary

2119. Bull, G. V., Enkenhus, K. R., and Tidy, G. H., Exit and re-entry problems, *Aero/Space Engng.* **17,** 6, 56–62, June 1958.

2120. Tan, H. S., On optimum nose curves for superaerodynamic missiles, *J. Aero. Sci.* **25,** 4, 263–264 (Readers' Forum), Apr. 1958.

Ballistics, Explosions

(See also Revs. 2083, 2084)

2121. Linder, B., Hirschfelder, J. O., and Curtiss, C. F., Theory of detonations. I—Irreversible unimolecular reaction; II—Reversible unimolecular reaction, *J. Chem. Phys.* **28,** 6, 1130–1147; 1147–1151, June 1958.

I. The composition, temperature, and pressure as functions of distance in a steady-state, plane gaseous detonation wave are studied. The effects of the coefficients of viscosity, diffusion, and thermal conductivity are included. The basic equations are set up for a gas in which the irreversible unimolecular reaction AB takes place with the release of energy. The topological nature of the solutions is discussed and some detailed numerical solutions are given. The numerical calculations (obtained by a point-by-point integration of the detonation equations) indicate a strong probability that there is a highest ambient pressure above which a steady-state detonation cannot take place, and indicate a possibility that there is an ambient pressure below which a detonation cannot occur. In the examples considered, there is strong coupling between the reaction zone and the shock zone so that the solutions never come close to the von Neumann "spike." If the Mach number is greater than unity, the solutions have an entirely different nature and exist for only a single ambient pressure rather than for a range of pressures. However, from hydrodynamical considerations, a detonation wave initiated from either a point or a fixed wall can become equivalent to the steady-state solutions only if the Mach number is greater than or equal to unity.

II. The effect of a back reaction on the chemical and thermal profiles in a steady-state plane gaseous detonation wave supported by an exothermic unimolecular reaction is considered. Just as in the irreversible case, considered in part I, the character of the solutions of the detonation equations change when the Mach number becomes greater than unity. However, in agreement with the conclusions of Wood and Kirkwood, for the reversible reaction, this critical Mach number has the value of unity only when it is defined in terms of the equilibrium velocity of sound.

From authors' summary by S. S. Penner, USA

2122. Osnovin, S. D., Methods and formulas for the calculation of concentrated explosive charges (in Russian), *Izv. Tomskogo Politekhn. In-ta* no. 84, 70–83, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5268.

A series of methods is compared for the calculation of explosive charges used for the disintegration of soils by explosions in rocky strata. The study has the aspect of a review, but does not adequately embrace even the most important items of the known material facts. In particular, it contains no references to the extensive foreign literature on the subject of the paper.

G. I. Pokrouskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2123. Brodskii, M. P., Action of an explosion in a solid medium (in Russian), Theory and practice of explosive drilling work in the mining industry, Moscow-Khar'kov, Ugleizdat, 1953, 66–117; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5267.

Existing formulas for the calculation of charges used in explosive work are compared. An examination is made of the prerequisites of a new theory, proposed by the author, based on different simplifications and assumptions, permitting the determination, with comparative ease, of the size of the charge necessary for the task of destruction of the stratum (up to a state of friability or ejection). A classification of rock strata is given on the basis of the proposed theory. In conclusion an examination is carried out of the breaking down of rock, directed explosions for ejections of rock, and also the influence of the explosion on the water permeability of the stratum. G. I. Pokrovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2124. Gilstein, J. B., Final report of Project Scamp, Sept. 1955 to Oct. 1956; New York University, Physics Dept., Coll. Engng., Contract NR 062193, x + 224 pp.

Report deals with an experimental model study of interaction between underwater explosion and floating structures. Explosion was created by exploding wires, electrically energized, at two different depths below the surface. Floating structure consisted of three spheres arranged in a line, elastically constrained such that they could only heave, pitch, or flex. The motions of the gas bubbles (resulting from exploding wires) and structures were recorded by a high-speed movie camera. Tests were run in a steel tank where the pressure was about 1/360 of one atmosphere. This permits the simulation on a small scale of the effects caused by gravity in large-scale explosions in the ocean. The mass of the structure was held constant but its stiffness was changed by means of springs so that its natural frequency was adjustable.

A theory, based on certain simplifying assumptions, was developed. Theoretical results were compared with experimental data. It was concluded that gravity plays a very important role in the phenomena; and that any future theory should take gravity into account. T. C. Tsu, USA

Acoustics

2125. Meecham, W. C., and Ford, G. W., Acoustic radiation from isotropic turbulence, *J. Acoust. Soc. Amer.* **30,** 4, 319–322, Apr. 1958.

Starting from the results of Lighthill [AMR **6** (1953), Rev. 654], authors investigate the form of the acoustic power spectrum for turbulence at Reynolds numbers large enough for an inertial sub-

range to exist. It is assumed that the turbulence is homogeneous, isotropic, and stationary, and that the turbulence Mach number is small. A generalization of Kolmogoroff's similarity principle is used to show that the space-time pressure correlation occurring in the formula for the spectrum can be expressed in terms of a function of a single variable. For high frequencies ($\omega >> c_0 M/L$), the spectrum is then found to be universal and of the form $\omega^{-7/2} M^{21/2}$, where ω is the acoustic angular frequency, M is the turbulence Mach number, c_0 is the velocity of sound, and L is the size of the large-scale turbulent eddies. For low frequencies, the spectrum depends on the large-scale eddies and is proportional to $\omega^4 M^3$.

D. W. Dunn, Canada

2126. Wiener, F. M., Sound propagation outdoors, *Noise Control* **4,** 4, 16–20, July 1958.

A procedure for estimating the attenuation of sound outdoors near the ground in excess of inverse-square law spreading loss.

From author's summary

2127. Thurston, G. B., Nonlinear acoustic properties of orifices of varied shapes and edge conditions, *J. Acoust. Soc. Amer.* **30,** 5, 452–455, May 1958.

The results of a study of the effect of shape and orifice edge conditions on the nonlinear acoustic properties of orifices are presented. The samples studied consisted of orifices of circular, rectangular, and square shape in thin orifice plates. Varied edge conditions considered are square, round, and symmetric and nonsymmetric beveled edges for circular orifices in thick plates. These samples were studied for sinusoidal volume velocity in the orifice. It is found that for all the symmetric samples the pressure contains odd harmonics while for the nonsymmetric sample a steady component and second harmonic component are superimposed on the odd harmonics. An equation for the pressure-flow relation is given which is applicable to both symmetric and nonsymmetric orifices.

From author's summary

2128. Nyborg, W. L., Acoustic streaming near a boundary, *J. Acoust. Soc. Amer.* **30,** 4, 329–339, Apr. 1958.

An approximate solution is developed for sonically-induced flow near a fluid-solid interface in terms of the irrotational oscillatory velocity distribution (u_a, v_a, w_a) in that vicinity. The principal condition on the validity is that the acoustic boundary-layer parameter $(\nu/\omega)^{1/2}$ should be small compared to the scale of (u_a, v_a, w_a) (where ω is the frequency and ν the kinematic viscosity). Applications are made to special situations, one case of particular interest being that of a small source near a rigid plane. The conclusion is reached that small compressible bodies, and especially resonant gas bubbles, resting on boundaries, are likely sites of pronounced microstreaming.

From author's summary by D. W. Dunn, Canada

2129. Zink, J. W., and Delsasso, L. F., Attenuation and dispersion of sound by solid particles suspended in a gas, *J. Acoust. Soc. Amer.* **30,** 8, 765–771, Aug. 1958.

Observations were made on audio-frequency sounds propagating through a gaseous medium containing small solid particles in suspension. Two effects were observed, the attenuation and the dispersion. The measurements were carried out by sending short trains of sine waves through the particle-filled gas and observing the changes in the transmitted train of waves after the particles settled out of the gas. The variation in arrival time of the pulse was used to determine the velocity change caused by the suspended particles. Changes in the amplitude of the received pulse made it possible to determine the additional attenuation due to the suspended particles.

The variations of the attenuation and velocity with frequency due to the particle-filled gas were obtained and the results compared with theory. The measured attenuation was found in good agreement with existing theory. The observed dispersion is satisfactorily accounted for by a theory that is introduced in this paper. The attenuation theory takes into account enhanced viscous and thermal losses caused by the suspended particles. The dispersion theory predicts the velocity shift resulting from changes of the heat capacity and density of the gas containing the suspended particles.

From authors' summary

2130. Hubbard, H. H., and Maglieri, D. J., An investigation of some phenomena relating to aural detection of airplanes, *NACA TN* 4337, 16 pp. + 7 tables + 23 figs., Sept. 1958.

Conventional noise-level measurements consisting of broad- and narrow-band frequency analyses were made for static ground tests of an unmodified and modified single-engine airplane. Also, listening data with the aid of ground observers were obtained in flight during cruise as well as for take-offs, landings, and power-off glides. The test results indicate that the external noise-level characteristics of the airplane, the propagation phenomena relating to the conditions of the problem, and the ambient or background noise conditions at the location are all significant factors in aural detection by ground observers.

From authors' summary

2131. Oyer, I., Franken, P. A., and Westervelt, P. J., Jet noise reduction by induced flow, *J. Acoust. Soc. Amer.* **30,** 8, 761–764, Aug. 1958.

The effect on the generation of jet noise by the secondary air induction of a modified jet nozzle is analyzed. It is shown that the combination of the secondary air with the primary jet air creates a new jet stream of larger area, lower velocity, and lower noise generation. The decrease in noise radiation is found in terms of the area of the combined jet stream. Detailed check of the theory is not possible at present because measurements of the areas of the combined jet streams have not been generally made along with measurements of the noise. However, it is possible to estimate the upper limit of the appropriate jet stream area in order to obtain the upper limit on noise reduction. The upper limit on noise reduction obtained from the theory is consistent with existing measurements. Qualitative conclusions from the theory with respect to the spectrum and directivity of the noise radiated by jets with modified nozzles are in accord with measurements.

From authors' summary

Micromeritics

(See also Rev. 1903)

2132. Litwiniszyn, J., Application of the equation of stochastic processes to mechanics of granular bodies (in English), 9th Congrès Intern. Mécan. Appl., Bruxelles Univ. 1957; **5,** 391–400.

Author develops a second-order partial differential equation governing the set in a granular medium as a function of two spacial coordinates. For the particular case of a "horizontally isotropic" incompressible medium the equation is reduced to a one-dimensional parabolic equation. Two solutions corresponding to given initial conditions are obtained and the predictions compared with experimental data. H. Deresiewicz, USA

2133. Brenner, H., Dissipation of energy due to solid particles suspended in a viscous liquid, *Phys. Fluids* **1,** 4, 338–346, July–Aug. 1958.

A general method is developed for calculating the *additional* mechanical energy dissipation incurred by the presence of solid particles suspended in an incompressible viscous fluid in laminar

flow. The development is applicable to flow in any apparatus within which the steady motion of a homogeneous fluid can be described by omitting the inertial terms in the Navier-Stokes equations or in which the motion occurs in concentric circles. The validity of the results obtained is limited to situations in which the particle dimensions are small compared to those of the apparatus in which the motion is occurring.

The technique, based largely upon a reciprocal theorem for the inertialess flow of viscous fluids, is employed to calculate the permanent pressure drop accompanying the passage of liquid through a bed of fluidized solids. Einstein's formula for the apparent viscosity of a dilute suspension of spherical particles is also deduced. By means of a new definition of suspension viscosity the heretofore different points of view advanced by Einstein, Jeffery, and Burgers are seen to be consistent with one another. From author's summary by J. S. McNown, USA

2134. Knoroz, V., The formation of natural bedding in the scouring of rivers (in Russian), *Gidrotekh. Stroit.* no. 4, 47–48, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6684.

Results of laboratory tests are described on the scouring of a channel formed in sand of medium coarseness 0.38 mm, containing larger inclusions of a diameter of 6.4 mm in quantities of 0.091, 0.168 and 0.231 relative to the total volume of the bottom.

With a mean flow velocity u exceeding the non-scouring velocity of the fine fraction u_0', but not exceeding $(0.6–0.7)\,u_0''$, where u_0'' is the non-scouring velocity of the coarse fraction, motion takes place in the form of ridges, both of the fine and the coarse material. The scouring process terminates by natural covering of the bottom by the large particles (self-bedding). At $u > (0.6–0.7)\,u_0''$, self-bedding does not take place, and the current carries away both the fine and the coarse fractions.

An approximate formula is given for calculating the depth of scouring. Author's conclusions require confirmation for other proportions of the coarse and fine fractions.

I. L. Rozovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2135. Vanoni, V. A., and Brooks, N. H., Laboratory studies of the roughness and suspended load of alluvial streams, Calif. Inst. Technol., Sedimentation Lab. Rep. E-68, 121 pp., Dec. 1957.

A total of 94 experimental runs was made in two laboratory flumes charged with fine sand of several size distributions. Special attention was given to the variation of the friction factor caused by the changing bed configuration and the damping effect of suspended sediment. The relationship between the sediment transportation rate and the hydraulic variables was also investigated. Most of the runs were made with the bed of the flume completely covered with loose sand but some special runs were made with the sand bed chemically solidified in place to prevent sediment transport while preserving the bed configuration previously generated by a natural flow of the same velocity with loose sand. The principal laboratory results are:

(1) The friction factor f for a stream with a movable sand bed may vary several fold, being highest at low or medium flow velocities and lowest at high velocity.

(2) The principal cause of the variation in f is the appearance of dunes at low or medium velocities and disappearance at high velocities.

(3) A secondary cause for the reduction in f for high sediment transport rates is the damping effect of the suspended sediment on the turbulence, and the concomitant reduction in the turbulent diffusion coefficients. The maximum observed reduction due directly to the sediment load was only about 28%.

(4) The discharge and sediment transportation rate are not unique functions of depth and slope because of the variable roughness. Slope (or shear) must probably be considered a dependent variable for alluvial streams because several equilibrium flows can yield the same slope and shear stress.

The laboratory data are compared with similar data for natural streams, and the most promising existing analyses for roughness and sediment load are discussed in the light of the present findings. In addition, a critical review of early and recent literature on the resistance of sediment-laden streams is presented.

From authors' summary

2136. Tverskaya, N. P., and Yudina, N. P., The results of an experimental investigation into the coagulation of water droplets (in Russian), *Trudi Leningr. Gidro-meteorol. In-ta* no. 5/6, 263–267, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6922.

2137. Kampf, G., Analytical and experimental investigations of throwing blowers (in German), *VDI-Forchungsheft* **24**, 466, 28 pp., 1958.

Solid particles such as wheat, sand and snow can be moved by rotating machinery either by moving a large quantity of air at high speed which pulls the particles along or by imparting the kinetic energy directly to the solid particles by the blades of the rotor. This latter machine, called a throwing blower, uses less power than the first kind, the pneumatic blower, since less useless energy is imparted to the ambient air.

The velocities of the solids, the power consumption, the height of throwing and the influence of the friction has been investigated analytically and experimentally. Relations useful for the design of these machines have been developed; an empirical relation for the power consumption is applicable for grain only. The principal unknown factor in the general equations is the friction which varies widely from dry grain to wet inelastic particles.

A design example is given. H. P. Eichenberger, USA

2138. Stanyukovich, K. P., Some principles of the movement of gas in its natural gravity field (in Russian), Mekhanika (MVTU 50), Moscow, Oborongiz, 1956, 101–119; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7596.

In the first part (motion of highly rarified gas) author establishes that for the study of the motion of a dust-like or gaseous medium in a highly rarified state, the basic equations in gas dynamics can be applied, taking into account the natural gravity field of these particles and assuming that the pressure of the medium is equal to zero. By disregarding the pressure entirely, author solves the one-dimensional problem of the focusing of the dust-like (or cold gaseous) cloud under the action of natural gravity. One-dimensional motions of a mass of gas which is in a twisted cylindrical state of symmetry are investigated. During this process pressure is disregarded, while the mass forces are taken in the form of

$$g = -\frac{4\pi G}{r^2}\int_0^r \rho r^2\, dr,$$

where G is the gravitational constant, ρ the density and r the distance from the axis of symmetry. When the initial parameters have certain values, periodic pulsations take place. Here the maximum absolute value of the vibration amplitude will be observed for particles situated on the periphery, while the maximum relative amplitude of oscillation will occur in the case of gas particles lying approximately at a distance equal to half the initial radius. For some values of the initial parameters the motion of the particles assumes hyperbolical and parabolical trajectories.

In the second part (motion of gas of arbitrary density) it is assumed that the gas cloud under the action of natural gravitation collects towards the center of symmetry, where the gas is subject to braking action when going through an impact wave, followed by a renewed dispersion to the periphery. An estimate is

given of the order of the values of the characteristics behind the impact wave, which is assumed to be powerful, while the velocity of the focused gas is assumed to be of the order of velocity when dropping without reference to pressure. In subsequent flow the peripheral mass of gas may acquire a velocity exceeding the parabolical and may be away from the center. For a given density in the dispersing gas the part taken by the mass going away into infinity is determined. At the end of the article the process of spreading of the impact wave over the rotating gaseous mass is qualitatively discussed. Author assumes that the processes investigated of the compression of the gaseous cloud and of the emission of the rotating gaseous masses might explain the origination of the system. The work contains printing errors.

M. L. Lidov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2139. Varazashvili, N. G., Experimental investigations on the distribution of the concentration of fine suspensions in a flow (in Russian), *Trudi Gruz. N.-i. In-ta Gidrotekhn. i Melior.* no. 3/16, 172–182, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6930.

Results are given of experiments with suspension-bearing flows at velocities of 1.58–5.75 cm/sec and grain size of the suspensions between 0.001 and 1.0 mm. Although the experimental channel of 9-m length and 0.28-m width was interrupted by a perforated screen at 7 m from the entrance, the measurements of the concentration field of the suspension satisfactorily agreed with those determined by calculation from the diffusion theory. Since the measurements of the concentration of the suspension were performed at three cross sections of the channel, it was found possible to calculate the intensity of precipitation of the suspension in the flow and compare it with the intensity of precipitation of a suspension in a liquid at rest considered at the same depths and concentrations of the solid phase during sampling as in the channel experiments. It was found that in a flow, precipitation was less in a ratio of 1 : 1.23 to 1 : 1.33 than in a static liquid.

Experiments were also made on the change of form of the suspension concentration fields in relation to the roughness of the bottom and the presence in the flow of "perforated structures."

The presentation is extremely concise and omits a number of details, for which reason it is fairly difficult, for instance, to estimate the degree of reliability of the relationship established between the precipitation of a suspension in a flow and in a static liquid.

M. A. Dement'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2140. Amelin, A. G., and Belyakov, M. I., Particle deposition from a stream on objects being flown about (in Russian), *Kolloid. Zh.* **18**, 4, 385–394, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5519.

An analysis is given of work devoted to investigating the deposition of suspended particles in the stream on objects being flown around. The basic parameters and correlations characterizing the process of deposition of the particles are established. It is shown that, by analogy with the processes of heat transfer and diffusion, the value of the coefficient of entrapment of the particles flowing around the objects can be expressed by

$$E = mS^n \qquad \left(E = \frac{n}{N\nu s\tau}, \quad S = \frac{\rho\nu d^2}{\mu D}\right)$$

in criterial form where E is the coefficient of entrapment expressing the relative quantity of deposited particles on the object, n the general quantity of drops of a given dimension deposited on the object, N the quantity of drops of a given dimension in the unit volume of the aerosole, ν the stream velocity at a distance from the object being flown around, s the middle cross section of the object, τ the time in seconds; m, n empirical coefficients; S Stokes' criterion, ρ the density of the drop, d the diameter of the drop, μ the air viscosity, D the size of the object. In order to obtain a reliable criterial relation of the type given above, experiments were carried out on the settlement of drops of transformer oil from the aerosol stream on cylinders. A description is given of the apparatus and procedure used in the experiments. A polydispersed aerosol was utilized; the cylinders on which it was deposited had diameters of 1 and 2.5 cm. The velocity of the air stream flowing round the cylinders was equal to 200–1600 cm/sec. As the result of the experiments, values for the coefficients m and n were obtained for the leading edge ($m = 7 \times 10^{-4}$ and $n = 3.5$) and trailing edge ($m = 2.66 \times 10^{-4}$ and $n = 0.54$) of the cylinder. It was established that complete settlement of drops $E = 1$ is accomplished when the value of $S = 170$.

Yu. F. Dityakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2141. Csanady, G. T., Deposition of dust particles from industrial stacks, *Austral. J. Appl. Sci.* **9**, 1, 1–8, Mar. 1958.

Paper is a very brief semi-empirical analysis of the industrial dust problem. A deposition formula is uncritically stated without reference to derivation. While mention is made of the modern theory of turbulence it is not clear to the reviewer how the author avails himself of this knowledge in attempting to treat the problem.

W. H. Hoppmann, II, USA

2142. Problems in the electric dust removal from flue gases (in German), *Z VDI* **100**, 12, 507–508, Apr. 1958.

2143. Karimov, A. A., An investigation of the air-filtering system of the D-54 engine (in Russian), *Trudi Vses. N.-i. In-ta Mekhaniz. S.-kh.* **23**, 42–81, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6519.

2144. Fuhs, A. E., Spray formation and breakup, and spray combustion, AFOSR TN 58-414 (Sundstrand Turbo, Pacoima, Calif., TN 4; AMF/TD no. 1199); 129 pp. + 26 figs. + 107 refs., Feb. 1958.

Report is a survey of literature on liquid spray behavior, particularly in jet propulsion devices. Part I, (pp. 1–76), "Spray formation and breakup," discusses the known means for atomizing liquids, and the mechanisms for jet and sheet breakup under environments of non-burning media. Factors influencing spray characteristics, and the disintegration of liquid jets and sheets are discussed, based on previous researches of Haenlein, Ohnesorge, Sauter, Schuebel, York, Stubbs, and Tek, Hagerty and Shea, and others. Deformation of drops moving at high velocity relative to the ambient fluid, and their subsequent breakup are discussed, based on previous work of Lane, Hinze, Magarvey, Taylor, Masugi, Hanson, Domick, Adams, Golitzine, and others. Further chapters are devoted to spray penetration, and to the discussion of various expressions for drop-size distributions (Rosin and Rammler, Nukiyama and Tanasawa, Log-probability function, Square-root function). Various kinds of mean diameters and their fields of application are tabulated. Several experimental sizing techniques and samplings are described. Various aspects of application of sprays in rocket motors are discussed.

Part II (pp. 77–129), "Spray combustion," deals with aspects of sprays associated with combustion and its preliminary phases, i.e., mixing of propellants, and evaporation of single drops, arrays of drops, and sprays. Previous research of Longwell and Weiss, NACA work by Ingebo and others, Froessling, Ranz and Marshall, Conkie and Savic, and others are described in detail, with formulas and graphs. Combustion of single drops in quiescent atmosphere is discussed based on the work of Godsave, Spalding, Goldsmith and Penner, Hall, Kobayasi, Graves, and others. Drop array studies of Rex, Fuhs, Penner, and Tanasawa and research on complete burners by Mayorcas, Anson, and Riviere, and others are critically examined.

This is an excellent and up-to-date survey of the present state of knowledge on the subject. It is concluded that the spray combustion process is a very complex interaction of many physical and chemical rate processes; it has not yet been fully cleared up in spite of the extensive theoretical and experimental research expended on it; design of a satisfactory combustion chamber and fuel spray system still requires trial and error methods, aided by reasonable semi-empirical correlations in terms of measurable quantities. K. J. DeJuhasz, Germany

2145. A tentative method for determining pickup efficiency of residual aerosol insecticides, Proc. Mid-Year Meet. Chem. Spec. Mfrs. Assoc., Inc., Freon Products Div., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., 4 pp. + 3 figs. + 2 tables + 3 refs., May 1957.

The important values for a residual insecticide aerosol are the percentage of the low-volatile ingredients that strike the target surface and thus perform their function, and the percentage that does not strike the target surface and are wasted and, what is worse, may represent a toxic hazard. Principle: the aerosol is directed from the container onto the target surface; container and target are weighed before and after spraying and the target pickup is calculated as a percentage of the weight of material sprayed. Percentage of low-volatile material in the aerosol is determined so that the efficiency of deposition can be calculated, and similarly the percentage not deposited also determined. Apparatus is illustrated and described and operation explained; sample data of actual test and their evaluation are included.
K. J. DeJuhasz, Germany

2146. Lyshevsky, A. S., The breakdown of a liquid-fuel film in air (in Russian), *Trudi Novocherkassk. Politekhn. In-ta* no. 33/47, 228–238, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6766.

A theoretical analysis is conducted of the stability of an interface between two fluids. Using the method of small perturbations it is assumed that the surface of the interface is occupied by a system of capillary waves due to the action of surface tension. The boundary conditions are then stated for the interface between two fluids, using very extensive assumptions, as a result of which an expression is obtained qualitatively determining the presence of one form of unsteady deformation of the interface. If this particular deformation develops more quickly than others it will cause separation of a filament from the interface. The resulting expression permits the determination of nondimensional parameters determining the breakdown of the film of a viscous fluid issuing from a narrow slit. Yu. F. Dityakin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2147. A tentative method for determination of the particle size distribution of space insecticide aerosols, Proc. Ann. Meet. Chem. Spec. Mfrs. Assoc., Inc., Freon Products Div., E. I. du Pont de Nemours & Co., Wilmington, Del., 4 pp. + 2 figs. + 5 refs., Dec. 1956.

The aerosol is drawn into a wind tunnel so that the individual particles deposit on a rotation microscope slide, on which the particles are counted and classified by size. Correction is applied to calculate the particle sizes in the original spray. This is an adaptation of methods previously described by Yeomans [U. S. Dept. Agric., Agric. Res. Service] and Bower. Apparatus and its operation are described; correction factor is explained; sample graph of particle size distribution is given; magnitude of error is estimated. K. J. DeJuhasz, Germany

2148. P'yankov, S. M., Theoretical and experimental investigations of apparatus; atomization jet for liquid fuel (heavy fuel oil) (in Russian), Thesis, Moscow, Mosk. In-ta Inzh. Zh.-d transp., 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4228.

Porous Media

(See also Rev. 2055)

Book—2149. Scheidegger, A. E., The physics of flow through porous media, New York, Macmillan Co., 1957, xii + 236. $14.

Author gives an almost complete survey of the present state of knowledge of fluid flow in porous media, obtained by studying a vast amount of literature to which the "Bibliography" refers chapter by chapter. Two introductory parts define the terms "porous media" and "fluids," and treat the measurement of pores and the consequences of the physical properties of fluids, such as viscosity, adsorption and miscibility. The third chapter on hydrostatics in porous media, taking into account the dimensions of the pores, is divided into four sections: the case of one fluid, two phases of one fluid, two immiscible fluids, and, in the fourth section, attention is given to wettability.

On this physical basis author treats the different methods of approach of flow in porous media. At first Darcy's law is treated, and generalized for compressible and for anisotropic media, after which a chapter deals with solutions of the differential equation resulting from it, in the cases of steady-state flow, and gravity flow with a free surface. In the chapter "Physical aspects of permeability" the flow of fluids in porous media is treated from the phenomenological point of view in which the correlation between permeability and the other properties of porous media is studied. The capillaric models and the hydraulic radius theory are treated.

Under the heading "General flow equations" the limitations of Darcy's Law are exposed and equations accounting for high flow velocities and for molecular effects are given. The last chapter deals with multiple phase flow, in which most attention is given to flow of immiscible fluids, extending Darcy's law by the analogy with single-phase flow, whereas in the case of miscible flow, only very slow displacement with very little mixing is considered, since for the phenomena of miscible displacement no satisfactory theory is yet available.

The work will be very useful for the research worker as it gives a summarization of information scattered over a vast number of publications. F. C. de Nie, Holland

2150. Van De Leur, D. A. K., A study of nonsteady groundwater flow with special reference to a reservoir-coefficient (in English), *Ingenieur* **70,** 19, 87–94, May 1958.

Author computes the discharge into an outflow channel of a system of parallel drainage channels in a flat region with alluvial or diluvial soils as prevail in the Netherlands. He assumes first that a steady vertical percolation at a constant rate p reaches a saturation state.

The mathematical solution is given through three equations which allow to compute respectively the rate q_b of groundwater flow per unit length of outflow channel, the elevation y_b of groundwater table halfway between two parallel outflow channels and the storage R_b of phreatic groundwater during the period b of constant percolation. The values of series appearing in the mathematical solution of the problem of the constant discharge p are given through three coefficients c_1, c_2, c_3, depending on the coefficient $J = 1/\pi^2(\mu L^2/kD)$ called by author reservoir coefficient. To evaluate c_1, c_2, c_3, author furnished suitable diagrams.

By means of the principle of superposition of effects, whose applicability was demonstrated by Edelman and Werner, author extends the use of the formulas to the case of nonsteady discharge.

For the recession, author deduces that at a certain time after the end of the rain the expressions of y, q and R, assume a simplified form. In particular in the expression of the rate of groundwater flow q_t from two sides into unit length of channel at the instant t, a coefficient c_4 depending on the ratio b/J between the

duration b of the percolation and the reservoir coefficient J can be introduced.

Author suggests some criteria for the evaluation, in practical situations, of the coefficient J in both the steady and nonsteady case, from the hydrograph of groundwater outflow or by ratio between the storage and the outflow of groundwater.

Author applies the proposed theory to the solution of two practical problems. The results of numerical computation are synthetized in appropriate graphs. Even if it is very synthetical, author's approach to the problem is a complete one.

Reviewer believes that the importance of the problem dealt with by the author and the interest of the proposed solution would have required a less synthetical treatment.

A. R. Russo Spena, Italy

2151. Barenblatt, G. I., and Shestakov, V. M., Determination of the filtration coefficient and active porosity in accordance with given addition of water to a dry soil with a horizontal pressurized water layer spread under it (in Russian), Razvedka i Okhrana Nedr. no. 8, 43–46, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8109.

A simple method is described for the determination of the filtration characteristics to cover the case where a dry, sufficiently homogeneous soil layer is underlaid by a horizontal resistant (pressurised) water layer. The method merges with that of pouring water into a perfect well and observing the changes with time of the free surface of the flow obtained in this way. The observations were carried out in either specially bored wells or in a central well. The method is based on the theoretical investigations of G. I. Barenblatt [*Prikl. Mat. Mekh.* **16**, no. 1, 1952].

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2152. Netunakhin, V. I., Determination of direction, speed of motion of subterranean waters and filtration coefficient of rocky strata by geophysical methods (in Russian), *Sb. Nauch. Trudi Kazakhsk. Gorno-Metallurg. In-ta* no. 14, 219–242, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8112.

The direction and velocity of flow of subterranean waters are determined by the method of a charged (loaded) body. A continuous saturated solution of kitchen salt is introduced into a well by means of a small bag of crystallized salt, suspended in such a way that the lower end of the bag was situated in the upper part of the range of depths [being investigated] for which the velocity was to be determined. In a rectangular system of coordinates in the function for time the displacements of the center of the isoline axis are applied parallel to the flow. The velocity is found by means of the angle of inclination of the tangential to the curve. The time interval between the measurements depends on the velocity of the flow. Should this be very small the time interval increases (some times up to 1–2 months). Experiments were carried out by the author in laboratory and field conditions in order to get more accurate information: (1) the method of introducing and the quantity of the electrolite required; (2) formulas for the calculation of the flow velocity and the connections between the flow velocity and the change of configuration and transformation of the isolines; (3) the relations of the quantity of salt required and the procedures to determine the influence of the diameter, depth of the well and its construction, geological sections and hydrogeological conditions. Author holds the view that a combination of the method of a charged body with the method of lateral electrical core sampling-soundings would lead to obtaining full characteristics for the velocity of the water motion and for the filtration coefficient of the rocky strata along the well. A. R. Shkirich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2153. Mkhitaryan, A. M., Calculation for filtration through an earthen dam on a permeable foundation with different coefficients for the filtration of the body and the foundation (in Russian), *Sb. Nauch. Trudi Kuibyshevsk. Industr. In-ta* no. 6 (part 1), 187–194, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8103.

An approximate hydraulic method of calculation is given for filtration through dams constructed on permeable foundations when the coefficients of filtration for the body of the dam and the foundation are different. When calculating the filtration through the upper and lower wedge-shaped parts of the dam, author divides the filtration region into two parts, taking as the horizontal dividing line the dam foundation. In the same way it is assumed that the lines of current, commencing in the upper slope, cannot enter the region of the permeable foundation. With this concept of the author, agreement is naturally impossible, especially in those cases when the foundation turns out to be more permeable than the body of the dam. For the solution of the problem of the length of the mean channels in the foundation of the upper and lower wedge-shaped parts author uses an old method, treating the track of the tunnel as an arc of the surrounding region. The calculation of the upper part of the lower wedge is carried out by N. N. Pavlovsk's obsolete formula $l = l/m_1$, where m_1 is the tangent to the angle of declination of the lower slope to the horizon. In contemporary practice more accurate relations are employed [e.g., G. K. Mikhailov, *Gidrotekhnika i melioratsiya* no. 1, 1952]. In his results author obtains a complex system of equations which he proposes to solve by means of graphical methods. Calculation curves are submitted for the case where the ratio of the filtration coefficients is equal to 10. Taking into account the remarks made, it is hardly possible to count on the practical application of the approximate method proposed by the author. In essential cases it would be easier to examine the model on the EGDA apparatus.

A. A. Uginchus

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2154. Kim, K.-O., An approximate method for calculating the filtration through earth dams on permeable foundations in the presence of draining (in Russian), *Sb. Nauch. Stud. Rabot. Mosk. In-ta Inzh. Vod. Khoz.* no. 3, 8–12, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6939.

An approximation method is discussed for calculating the filtration flow and drainage curve of an earth dam on a permeable foundation of limited thickness in the presence of buried pipe drains in the body of the dam.

The essence of the method consists in utilizing the Dupuy formula on the assumption of the existence of an "active region," the dimensions of which, depending on the head in the upper pound, are determined by an empirical formula obtained on the basis of experimental data reduced to restricted limits.

V. I. Aravin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2155. Tsarevich, K. A., and Kuranov, I. F., The calculation of the discharge from a central borehole in a circular stratum in the presence of elastic conditions (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 8, 9–34, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6942.

The problem is investigated of the inflow of liquid in elastic conditions of filtration to an ideal borehole in a homogeneous, isotropic, cylindrical stratum of finite or infinite radius coaxial with it. The liquid pressure on the bore wall is assumed to be constant. The solution of the equation of axially symmetrical filtration in elastic conditions corresponding to a coefficient of piezoconductivity of unity and a pressure drop at the bore walls also of unity is analyzed. First, as observed by the authors, this solution was presented by A. F. van Everdingen and W. J. Hurst

[*Petrol. Technol.* **1**, no. 12, 1946], and is now applied by the present authors to the solution of the generalized problem. A numerical calculation is exemplified, tables and graphs being given for the values of the discharge flow and total withdrawal of liquid from the stratum according to the solution of Everdingen and Hurst for a stratum of finite radius corresponding to $20-10^6$ times the radius of the borehole, over a large range of values of the non-dimensional time constant. The values thus obtained are tabulated to express the discharge flow and total withdrawal of liquid from the stratum for the generalized problem under consideration. For small values of the nondimensional time constant, asymptotic formulas are given, and the limits of their applicability defined. A particular sequence is recommended for performing the calculation in accordance with the tables and graphs provided, and some examples of calculation are shown.

G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2156. Shestakov, V. M., Some problems in the modelling of unsteady filtration (in Russian), Problems of the filtration analysis of hydraulic engineering structures, no. 2, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1956, 129–139; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6944.

The known methods of modelling unsteady filtration are discussed for the case of modelling in slot and bottom-flow launders without accounting for inertia forces [V. I. Aravin, *Izv. n.-i. in-ta gidrotekhn* **23**, 1938; **30**, 1941]. An additional method is suggested of modelling bottom sediments with allowance for the influence of capillary water in the investigation of unsteady filtration processes by means of bottom-flow launders. The exposition is illustrated by examples.

Further, author deals with the problem of nondimensional representation of the boundary conditions in problems in which the bottom sediment is bounded by water courses, the levels of which vary according to predetermined laws.

As an example, results are given of calculations on a hydraulic integrator, according to V. S. Lukyanov, of the depression curves of a homogeneous earth dam in the case of a falling water level in the upper pound. The resulting curve of the change in the mean gradient of the depression curve within the limits of the upstream slope of the dam in relation to the mean fall in level of the upper pound and the reduced rate of change in level can be applied with sufficient accuracy also in a number of other cases of values of the ratio of the rate of fall of the levels in the upper and lower pounds approaching those experimentally determined.

M. M. Semchinova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2157. Minskii, E. M., and Burshtein, M. L., Approximate calculation of the inflow of gas into a well, simultaneously draining off several gas-containing strata (in Russian), *Trudi Vses-neftegaz. N.-i. In-ta* no. 8, 262–279, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8096.

The total yield of a well draining several isolated layers is given in the form of the sum of yields, corresponding to each level. Pressures on the faces of separate layers, determining th yield of gas corresponding to the given layer, differ from each other by the weight of the gas column between the layers and the friction losses, corresponding to the actual output; the connection between yield and pressure drop is determined by the known two-term formula. On the assumption of the equality of the differences of squares of the layer and face pressures of a certain magnitude, equal for all the layers, a formula is deduced showing this value through the yield of the separate layers, and also some approximate correlation, representing it in the form of a two-term dependence of the usual type for the total yield of the well. The deduced formulas are used for the approximate solution of the problem on the inflow of gas to the well, draining a layer of irregular permeability, and also for approximate calculations for the treatment of multilayered gas sources for wells, simultaneously draining several gas-bearing strata. The problem is also investigated of the selection of compactness of perforation, guaranteeing a constant specific resistance over the whole capacity of the layer.

G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Hydrology, Oceanography, Meteorology

(See Revs. 1815, 1827, 1860, 1861, 1864, 1865)

Naval Architecture and Marine Engineering

2158. Tamiya, S., Studies on the law of comparison of the resistance of ships (in Japanese), *Rep. Inst. Indust. Sci., Tokyo Univ.* **7**, 2, Feb. 1958.

The law of comparison of the resistance of ships is considered. The total resistance coefficient r is supposed as a sum of r_f, r_w, r_{wf}, r_e and r_k, where r_f is the function of ship form and Reynolds' number R_N, r_w that of ship form and Froude's number F_N, r_e that of ship form, r_k, that of surface roughness, and r_{wf} is the resistance increment of r_f, r_w and r_e due to the motion of ships in the actual fluid.

Taking the effect of R_N into the terms of r_f and r_{wf}, following results are obtained:

$$\frac{\partial r_f}{\partial r_{f_0}} = 1 + K_1, \quad \frac{\partial r_{wf}}{\partial r_{f_0}} = 0 \quad \text{for} \quad F_N \leq 0.23$$

$$\frac{\partial r_f}{\partial r_{f_0}} = 1 + K_1, \quad \frac{\partial r_{wf}}{\partial r_{f_0}} \neq 0 \quad \text{for} \quad F_N > 0.23$$

where r_{f_0} is Schoenherr's frictional coefficient.

The K-values for the two-dimensional motion derived in the author's previous paper [*J. Soc. Nav. Arch. Japan* **88**, 25–42, Sept. 1955] are now converted to K_1 for the three-dimensional motion in the present paper. The K- values are compared with experimental results in two- and three-dimensional flow and fairly good agreement has been obtained.

The r_k-values for actual ships estimated by the present method are recognized to be approximately independent of ships speeds and forms.

Finally, the estimated r and effective horse power were compared with measured ones. From these investigations author has found that the present method results in good agreement with actual ship records adopting r_k of 0.00075 for riveted ships and 0.0002 for very smooth surface of welded hulls. As regards ordinary welded ships he recommends the r_k-values of 0.00025–0.00030.

From author's summary by T. Inui, Japan

2159. Reiss, H. R., The dynamics of a gravity towing system, *David W. Taylor Mod. Basin Rep.* 1040, 45 pp., July 1957.

Besides self-propulsion, the most popular ship-model testing technique device is called gravity dynamometer. The tow force is applied through an intricate system of two lines and pullies by falling weights. No significant dynamic effects occur in still

water resistance tests; seaworthiness investigations, however, necessitate an analysis of the dynamic behavior of the system. Paper derives the linearized equations of motion of the six-degrees-of-freedom system neglecting damping. Techniques for determining the elastic and inertia coefficients entering the equations are also described.

It is shown that the natural frequencies of the system are of interest since wave test conditions exist when the excitation frequency might coincide with the natural frequency of the system. Some well-known anomalies are accounted for which are observed during seaworthiness tests with the gravity towing system, and it is pointed out that certain test results might be due to the dynamic characteristics of the towing system and have little relation to the seaworthiness properties of the ship model tested.

Reviewer recommends the results of this very carefully and precisely written paper to workers in the field of ship model testing. It is regretted that the author's obvious competence and impressive savoir-faire of dynamics is diluted by masticatory ruminations of elementary mathematics; educating the illiterate simpleton, while boring himself and his peers.

Self-propulsion in waves is compared to various dynamic towing systems, including the one analyzed in paper by this reviewer et al ["Scale effects on ship motions, Trans. 11th Gen. Meet., Amer. Towing Tank Conf., 1957, **1**, 195–213; also *David Taylor Mod. Basin Rep.* 1099, 1957]. V. G. Szebehely, USA

2160. Fay, J. A., The motion and internal reactions of a vessel in regular waves, *J. Ship Res.* **1**, 4, 5–14, Mar. 1958.

Force distribution on a vessel moving in regular waves is analyzed using "cross-flow" hypothesis. Expressions for pitching and heaving of vessel, bending moment and shear of hull are obtained and compared with ship-model results of Lewis. Fair agreement is found for ship motion but not for bending moment.

R. N. Arnold, Scotland

2161. Okada, S., Investigation on the effect of the angular velocity of steering upon the performance of rudder (in Japanese), *J. Soc. Nav. Arch. Japan* **103**, 81–89, July 1958.

2162. Mazur, Yu. Yu., The two-dimensional problem of the maneuverability of a ship (in Russian), *Trudi Vladivostoksk. Vyssh. Morekhod. Morekhod. Uch-shche* no. 1, 3–23, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6737.

An approximate solution is suggested for the two-dimensional problem of the steady circulatory motion of a ship. The ship is substituted by a dihedral of finite length. The radius of the boundary of the dihedral is determined by its length/breadth ratio, L/B. The rudder is simulated by a small segment of the arc of large radius passing through bow and stern. The length of this arc is identical with the ratio of the area of the rudder blade to the products of the draft of the ship by its length, F/TL. A conformal representation is obtained for the outline of the analytical contour (area z) on the outline of the unit circle (area Φ). In the vicinity of the point $\Phi = \infty$, resolution into a Laurent series leads to

$$z = k\Phi + k_0 + k_1\Phi^{-1} + k_2\Phi^{-2} + \ldots$$

Applying the theory of the unsteady motion of a two-dimensional contour in an ideal fluid [N. E. Kochin, I. A. Kiebel, N. V. Rose: "Theoretical hydromechanics," 1941, Vol. I, pp. 267–278], author obtains a complex flow potential for the motion of a ship along a turning circle, and thence for the forces acting on the ship.

An equation of motion is derived which author restricts to the three first coefficients of the Laurent series, and he considers these to be real on the argument that, on inspection of the first six coefficients of the series, the last three are found to be small compared with the first three, while the imaginary parts of all six coefficients are small compared with the real parts.

The laws of variation of the drift angle and angular velocity of the ship are determined. It is suggested that the value $\epsilon = \omega L/\nu$ may be used as a universal criterion for the maneuverability of a ship. Applying additional assumptions which, as the author remarks, still need experimental confirmation, the influence of trim and hull form on the maneuverability of a ship are investigated.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2163. Sakkovetz, O. I., The influence of rolling on the stresses in trawl warps (in Russian), *Ryb. Kh-vo* no. 5, 76–80, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3098.

An estimate is made of the maximum possible stress in the trawl warps (used for towing a trawl net). The calculation standard is regarded as being the condition in which the trawl is being hauled with the ship broadside to waves in resonance with the ship's rolling period. It is assumed that the vertical amplitude of roll is the same as the wave amplitude. On the assumption of zero phase shift between scend and roll, the incremental velocity of the warp end due to rolling is determined, and, as a result of motion of the trawl net with this velocity, the additional load on the warp can be calculated.

G. V. Sobolev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2164. Remez, Yu., The influence of certain elements of a vessel on choice of a method of weathering a storm (in Russian), *Mor. flot.* no. 5, 14–15, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4324.

An attempt is made to give a theoretical explanation of the behavior of a ship in a storm. Selection of the method of weathering a storm is made from the condition that the vessel should not develop a resonance during pitching. Investigation is based on the joint examination of the formula for the apparent wave period

$$\tau = \frac{\lambda}{1.25\sqrt{\lambda} - 0.514\nu \sin\alpha}$$

and of the approximate expression for the period of natural longitudinal oscillations of a vessel

$$\tau_k = 2.53\sqrt{T}$$

In this λ is the wave length; ν the velocity of the vessel in knots; α the course angle of the wave crest measured along the board of the vessel; T the draught of the vessel at midships.

Various stages of the relationship between the wave length and the length and draught of a vessel, directions and velocity of the motion of a ship are examined. Furthermore, the condition for elimination of aggravated lateral rolling of a vessel in the choice of a method of weathering a storm is given.

A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2165. Cumberbatch, E., Two-dimensional planing at high Froude number, *J. Fluid Mech.* **4**, 5, 466–478, Sept. 1958.

Starting with Lamb's formulation of the problem for the effect of an arbitrary steady pressure on the surface of a stream, and utilizing the Wagner thin airfoil-planing surface analogy, an iteration process based upon a series expansion in inverse powers of Froude numbers is utilized to solve the integral relation for the pressure on the planing surface. Results obtained agree with those given earlier by Maruo and by Squire.

Solutions are obtained for the flat plate and the parabolic-shape plate and an interesting result obtained is that, for high Froude numbers, there always exists a linear combination of the two flows which corresponds to a wave drag condition only (drag due to rise or splash along the surface having been eliminated). This corre-

sponds to a minimum drag condition—the drag in this case being considerably lower than that corresponding to wave plus splash.
S. F. Borg, USA

2166. Schwanecke, H., Contribution to the theory of hydrofoils (in German), *Schiffstechnik* **5**, 26, 71–80, Apr. 1958.

The additional velocities induced by the free water surface, and the wave system were determined for the plane case of a submerged lighting surface, under the assumptions of inviscid and incompressible flows, small perturbations, and of the validity of thin airfoils. The flow over the lighting surface was assumed supercritical. T. P. Torda, USA

Friction, Lubrication and Wear

(See also Rev. 1889)

2167. Allen, G. P., Buckley, D. H., and Johnson, R. L., Friction and wear with reactive gases at temperatures up to 1200° F, *NACA TN* 4316, 12 pp. + 15 figs., Sept. 1958.

Friction and wear experiments were conducted to explore the effects of high temperature, varied chlorine content, sulfur catalysis, and preformation of sulfide films on boundary lubrication with reactive gases. Dichlorodifluoromethane (CF_2Cl_2), chlorotrifluoromethane (CF_3Cl), and sulfur hexafluoride (SF_6) gases were used to lubricate M-1 tool steel riders sliding on M-1 tool-steel disks at temperatures up to 1200 F. A 3/16-inch-radius hemisphere rider under a load of 1200 grams contacted the flat surface of a rotating disk; the usual surface speed was 120 fpm. In some cases, alloys other than M-1 tool steel were used for the rider specimen.

CF_2Cl_2 was more effective than CF_3Cl as a lubricant at all temperatures. The addition of small amounts of SF_6 to the gases improved lubrication. The SF_6 was considered to act as a catalyst to improve the chloride reaction at the slider interface. Sulfur hexafluoride alone is capable of giving reduced wear but does not reduce friction significantly for tool steel. Pretreatment by sulfurizing caused wear reduction both in air and in SF_6. At 600 F, nickel alloys that contained substantial silicon and were lubricated with SF_6 gave low friction and wear with negligible corrosion. Of the iron, copper, and nickel alloys studied, the silicon-nickel alloys gave the best results. Corrosion is a very important problem with tool steel operating at high temperatures in these gases. From authors' summary

2168. Atack, D., and Tabor, D., The friction of wood, *Proc. Roy. Soc. Lond.* (*A*) **246**, 1247, 539–555, Aug. 1958.

Earlier work, especially on metals, has shown that the friction of unlubricated solids is largely due to strong adhesion occurring at the regions of real contact; in addition, part of the friction may arise from the ploughing of the softer surface by asperities on the harder. The present paper shows that the friction of wood may be explained in a similar way, that is, it arises from an adhesion term and a deformation or ploughing term. In particular, it is found that the moisture content may have a profound effect—not necessarily a collateral one—on each of these terms.

The friction was studied between balsam wood (*Abies balsamea*) and surfaces of steel and polytetrafluoroethylene (PTFE). The most revealing results are obtained when steel or PTFE spheres are slid or rolled over the wooden surface. The rolling friction is found to be due to internal friction or hysteresis losses in the wood and not to surface interaction. It is essentially the same for both steel and PTFE spheres. As the moisture content is raised from 0 to 30% the rolling friction increases and then remains constant; this is apparently due to changes effected in the mechanical rather than the surface properties of the wood.

In contrast, the sliding friction is found to depend both on the moisture content of the wood and on the chemical nature of the other surface. For a hard slider of a given material under specified moisture conditions the sliding friction F_s may be expressed as the sum of two terms

$$F_s = F_D + F_A;$$

F_D is the tangential force involved in deforming the wood and is directly related to the internal friction or hysteresis losses in the wood itself. It corresponds to the rolling friction. F_A is the tangential force required to overcome interfacial adhesion. This is specific to the surfaces. It is high for steel whatever the moisture content of the wood, showing that the adhesion, which is probably due to hydrogen bonding, is strong in both cases. For PTFE the friction is fairly high when the wood has a low moisture content, implying a relatively strong adhesion, but it is very low when the moisture content exceeds 30 to 40%. This emphasizes the importance of surface structure in the adhesion term of friction in contrast to the deformation term which is essentially a bulk phenomenon. From authors' summary

2169. Dorfman, L. A., Frictional resistance of a rough disc rotating in a housing, *Soviet Phys.-Tech. Phys.* **3**, 1, 150–152, Aug. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28**, 1, 170–172, Jan. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Formula for the frictional resistance of a rough disk rotating in a housing is derived and compared with the experimental results.
From author's summary

2170. Klaus, E. E., Hersh, R. E., and Pohorilla, M. J., Slope index—an expression for viscosity-temperature characteristics, *Lubrication Engng.* **14**, 10, 439–446, Oct. 1958.

The viscosity-index method for indicating the change in the viscosity of a lubricant with temperature has several disadvantages. The present paper describes a system for presenting viscosity-temperature data which has been devised to remedy these advantages. From authors' summary

2171. Ocvirk, F. W., and DuBois, G. B., Surface finish and clearance effects on journal-bearing load capacity and friction, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-134, 8 pp.

A method of relating surface finish to minimum oil-film thickness and the corresponding load capacity of plain journal bearings is presented with supporting experimental data. The effect of clearance on load capacity and friction are shown on graphs indicating an optimum bearing clearance.
From authors' summary

2172. Tondl, A., The motion of a journal in a bearing in the unstable region of equilibrium position of the centre of the journal (in English), 9th Congrès Intern. de Mécan. Appl., Bruxelles Univ. 1957; **5**, 95–107.

Author presents an analysis of the whirl of a journal in a bearing. The case analyzed is basically that of a perfectly balanced rigid rotor in a horizontal bearing. Results are shown graphically for both full and half bearings.

Analysis starts with the tangential and radial forces on journals as derived by D. Robertson [*Phil. Mag.* **15**, pp. 113–180, 1933]. A deformed ellipse about the equilibrium position is assumed as the path of the whirl. A criterion of zero work input per whirl yields the ratio of semi-axes of the whirl ellipse and the frequency.

Reviewer believes background advances of this paper will reinforce general knowledge of the problem as attacked recently by several others, particularly those reported in AMR **11** (1958), Revs. 2896, 3847, 3850 and 4307. E. J. McBride, USA

2173. Nelson, G. G., and Gatcombe, K., Oscillating journal-bearing oil-film study, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-156, 7 pp.

A 1-in.-diam steel journal was supported in two non-test bearings. It was oscillated through a total angle of 30 deg with nearly simple harmonic motion. A single test bearing 1-in. diam and 1 in. long was supported in space by the journal, the loading cable, and the strain-gage system. Hydrodynamic films were or were not established, depending upon the load, the speed, and the phase of oscillation. In general, three characteristic variations of friction were observed: (a) A sinusoidal variation; (b) a constant value; (c) a special form in which there was a definite increase in the friction at the ends of the stroke, which gave a clear indication that the film changed thickness at the ends of the stroke. The electrical resistance system also clearly indicated the relative thickness of the film at various phases of oscillation, showing that a film may be established at mid-stroke and that boundary film conditions may exist at the ends of the stroke. Measured coefficients of friction for the midstroke phase ranged from 0.071 to 0.013. From authors' summary

2174. Jacobson, M. J., The finite length partial fitted journal bearing with axial oil groove, *Quart. Appl. Math.* **16,** 1, 1-10, Apr. 1958.

Author shows that the effect of side leakage on the solution of the Reynolds equation for a finite-length fitted journal bearing may be treated as a problem of the Sturm-Liouville type. By this method solution for pressure distribution is obtained as infinite sequence of terms corresponding to eigenvalues which are the roots of a power series. In certain conditions convergence is rapid, and solution is illustrated for partial bearing subtending 30° and having *length/diameter* ratio = 1/2; graphs show axial and circumferential pressure variation for oil supplied under pressure to inlet edge. G. D. S. MacLellan, England

2175. Wunsch, H. L., Design data for flat air bearings under steady load conditions, *Engineer, Lond.* **206,** 5355, 411-415, Sept. 1958.

While air bearings have been used for a variety of purposes both in the laboratory and also, to some extent, in industry, there is a definite lack of published information necessary for their systematic design. In other words, while it is not too difficult to design an air bearing for a particular purpose and to make it work, it is by no means so easy to get the optimum design from the point of view of maximum stiffness, maximum load and economic air flow. From author's summary

2176. Utsumi, T., Kaneko, R., and Okamoto, J., Vibration of pivot-type ball bearing (in English), *J. Mech. Lab. Tokyo* **3,** 2, 61-69, 1957.

The ambiguity in this paper was indistinguishable from that in the translation, and this, with the apparent level of experimental technique described, makes any conclusions rather dubious. The first paragraph follows: "Noise and vibration of the miniature pivot-type ball bearing in high speed were measured. Driving method of bearing is to spin a top on the bearing."

"By this way, the following were obtained: (1) Movement of the top is more stable when ball-pivot was used than cone-pivot. (2) Free running time is constant by air frictional resistance regardless of finishing of the bearing element. (3) Frequency spectrum is similar to the common ball bearing. (4) Excepting the vibration dependent to unbalance mass, the vibration is proportional to the roundness of outer-race. (5) The order of bearing elements which influence the vibration is (1) pivot, (2) ball, (3) outer-race."

C. C. Osgood, USA

2177. MacConochie, I. O., and Cameron, A., The measurement of oil-film thickness in gear teeth, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-142, 6 pp.

The voltage drop across thin oil films when a constant current of 1 amp is passed, i.e., the discharge voltage, is used to measure the oil-film thickness between loaded gear teeth while running. It is found that the thickness at the pitch line is between 1 and 4×10^{-4} in., which varies slightly with the viscosity and rather more strongly with load. The thickness at the tips and roots is quite dependent on the tip relief. The conditions here may explain the difference between disk and gear tests. These experimental values are compared with theoretical work and are shown to be of the same order of magnitude. From authors' summary

Letters to the Editor

2178. Concerning AMR **11,** Rev. 389 (February 1958): Mahalingam, S., Transverse vibrations of power transmission chains, *Brit. J. Appl. Phys.* **8,** 4, 145-149, Apr. 1957.

Source was given as *J. Appl. Phys.*, volume number 28. The editors regret this error.

2179. Concerning AMR **8** Rev. 2322 (June 1958): **Hunziker, R. R., Heat transfer in turbulent pipe flow.**

In the above mentioned review of my report, Prof. Corrsin attributes to me statements and opinions which are not printed in the said report and contradict what I have written. The following comments are in order:

1. Since what I have stated about the "laminar sublayer" is in accord with generally accepted notions which are shared by Prof. Corrsin, I assume that his statement that I "claim that the laminar sublayer is a fiction" is due to a misunderstanding of what is written in pages 15 and 16. In the introductory section 1.4 of the report (pp. 14-17) I have discussed Pai's solution of the Reynolds equations [*J. Appl. Mech.* **20,** 1, 109-114, March 1953, *J. Franklin Inst.* 256, 4, 346, October 1953], and I have denied a criticism [AMR **6,** Rev. 3156, p. 473, Oct. 1953] based on the fact that in Pai's expression "the corresponding turbulent shear stress remains finite in the laminar sublayer except at the wall itself." According to Pai's expression the Reynolds stress diminishes continuously and monotonically toward the wall and in a very thin region close to the wall is negligible in comparison with the laminar shear stress. In p. 16 of the report I mentioned Laufer's measurements near the wall with the purpose of showing that from the nature of the turbulence phenomenon it can be induced that the turbulent Reynolds stress, even if negligible, cannot drop abruptly to zero in the finite laminar sublayer. A similar inference was expounded some years ago by Prof. Corrsin when he wrote [AMR 3, Rev. 1542, August 1950, p. 244] "...the synthetic sharp partition of the flow field into "laminar," "buffer" and "turbulent" regions is merely intended as a crude artifice for approximate calculations, and is not taken literally by serious researchers in turbulence. It is unlikely that anyone working in turbulence research believes that there is any measurable region of literally zero fluctuation level near a solid surface."

In my report, instead of naming the laminar sublayer with "literally zero" Reynolds stress a "crude artifice" I called it a "useful mathematical abstraction." Certainly I have indicated that in the "laminar sublayer" the Reynolds stress need not be identically zero.

2. The distributions of Pai which are called postulates by Prof. Corrsin are solutions of the Reynolds equations. They are free of any logical error and represent the experimental data fairly well. If the introduction of polynomials of a special form is considered a postulate in Pai's deductions, the same noun must be

applied to Elrod's [*J. Aero. Sci.* **24**, no. 6, June 1957] representation of the velocity field in the wall neighborhood. As far as I know, there is no general existence theorem on the solutions of the Navier-Stokes equations which assures the analyticity (representation by a convergent power series of four variables) of the velocity fluctuations as assumed by Elrod [see for example G. Birkhoff, "Hydrodynamics," p. 32 and footnote].

Notwithstanding that Elrod results are, as those of Pai, based on special hypotheses, Prof. Corrsin does not call them postulates, and confers to them an apodictical value.

3. In relation to the contributional aspects I want to point out that the report shows that the application of Pai's distributions to Laufer's experimental data (for Re = 50,000) gives a radial average value of the eddy diffusivity for momentum ϵ_M which is about one half of the values used in former calculations giving generally high heat transfer rates.

Other results of the report have been already published [*J. Aero. Sci.* **24**, no. 10, October 1957 and *J. Franklin Inst.* **265**, 3, pp. 205-225, March 1958].

My calculations are based on the ideas of Reynolds, Prandtl, Taylor, von Karman and Pai, and show a fair agreement with experimental heat transfer data. As other analyses supported on these concepts, they may be used as a basis for interpretation and prediction until a turbulence theorist makes a fundamental contribution to the "basic problem of turbulent heat transfer."

I welcome Prof. Corrsin's opinion that my analysis "may be of engineering use" because this was one of the final objectives of the project.

R. R. Hunziker, USA

Books Received for Review

BEEDLE, L. S., Plastic design of steel frames, New York, John Wiley & Sons, Inc., 1958, xiii + 406 pp. $13.00.

BERNHARDT, E. C., edited by, Processing of thermoplastic materials (Plastics Engineering Series), New York, Reinhold Publishing Corp., 1959, xv + 690 pp. $18.00.

CRANDALL, S. H., edited by, Random vibration, Cambridge, Mass., Technology Press of MIT, 1958, viii + 406 pp. $10.00.

ENGLISCH, C., Kolbenringe. Volume II. Betriebsverhaltnisse und Prufung, Wien, Springer-Verlag, 1958, vi + 331 pp. $14.75.

ETKIN, B., Dynamics of flight; Stability and control, New York, John Wiley & Sons, Inc., 1959, xiv + 519 pp. $15.00.

GARNIR, H. G., Les problemes aux limites de la physique mathematique, Basel, Birkhauser Verlag, 1958, 234 pp. Fr. 29.00.

HIX, C. F., Jr., and ALLEY, R. P., Physical laws and effects, New York, John Wiley & Sons, Inc., 1958, 291 pp. $8.75.

HODGE, P. G., Jr., Plastic analysis of structures, New York, McGraw-Hill Book Co., Inc., 1959, xiv + 364 pp. $10.50.

HRYNISZAK, W., Heat exchangers, New York, Academic Press, Inc., 1958, xii + 343 pp. $10.00.

Industrial Noise Manual, Detroit, Mich., American Industrial Hygiene Association, 1958, vii + 180 pp. + index. $7.50 (Paperbound).

IWINSKI, T., Theory of beams (translated from the Russian by E. P. Bernat), New York, Pergamon Press, 1958, 85 pp. $3.50.

JURY, E. I., Sampled-data control systems, New York, John Wiley & Sons, Inc., 1958, xv + 453 pp. $16.00.

KREITH, F., Principles of heat transfer, Scranton, Pa., International Textbook Co., 1958, xiii + 553 pp. $11.00.

MERIAM, J. L., Mechanics. Part I. Statics, 2nd edition, New York, John Wiley & Sons, Inc., 1959, xiv + 393 pp. $5.00.

MOTT, N. F., and JONES, H., The theory of the properties of metals and alloys (reprint of 1936 corrected sheets), New York, Dover Publications, Inc., 1958, xiii + 326 pp. $1.85 (Paperbound).

NEUBAUER, R., Temperatur und Spannungsverteilung in ausgemauerten zylindrischen Reaktionsgefassen, Berlin, Springer-Verlag, 1958, 110 pp.

Physics and Heat Technology of Reactors (translated from the Russian), New York, Consultants Bureau, Inc., 1958, v + 174 pp. $22.50.

PLUNKETT, R., edited by, Colloquium on mechanical impedance methods for mechanical vibrations, ASME Annual Meeting, New York, 1958, New York, American Society of Mechanical Engineers, 1958, 145 pp. $5.50 (Paperbound).

Revue de Mathematiques Pures et Appliquees. Volume II. Hommage a S. Stoilow pour son 70th anniversaire, Bucarest, Institutul de Matematica al Academiei R. P. R., 1957, 559 pp.

ROUSE, H., editor, Advanced mechanics of fluids, New York, John Wiley & Sons, Inc., 1959, xiv + 444 pp. $9.75.

SPALDING, D. B., and COLE, E. H., Engineering thermodynamics, London, Edward Arnold Publishers, Ltd., 1958, viii + 375 pp. 28s.

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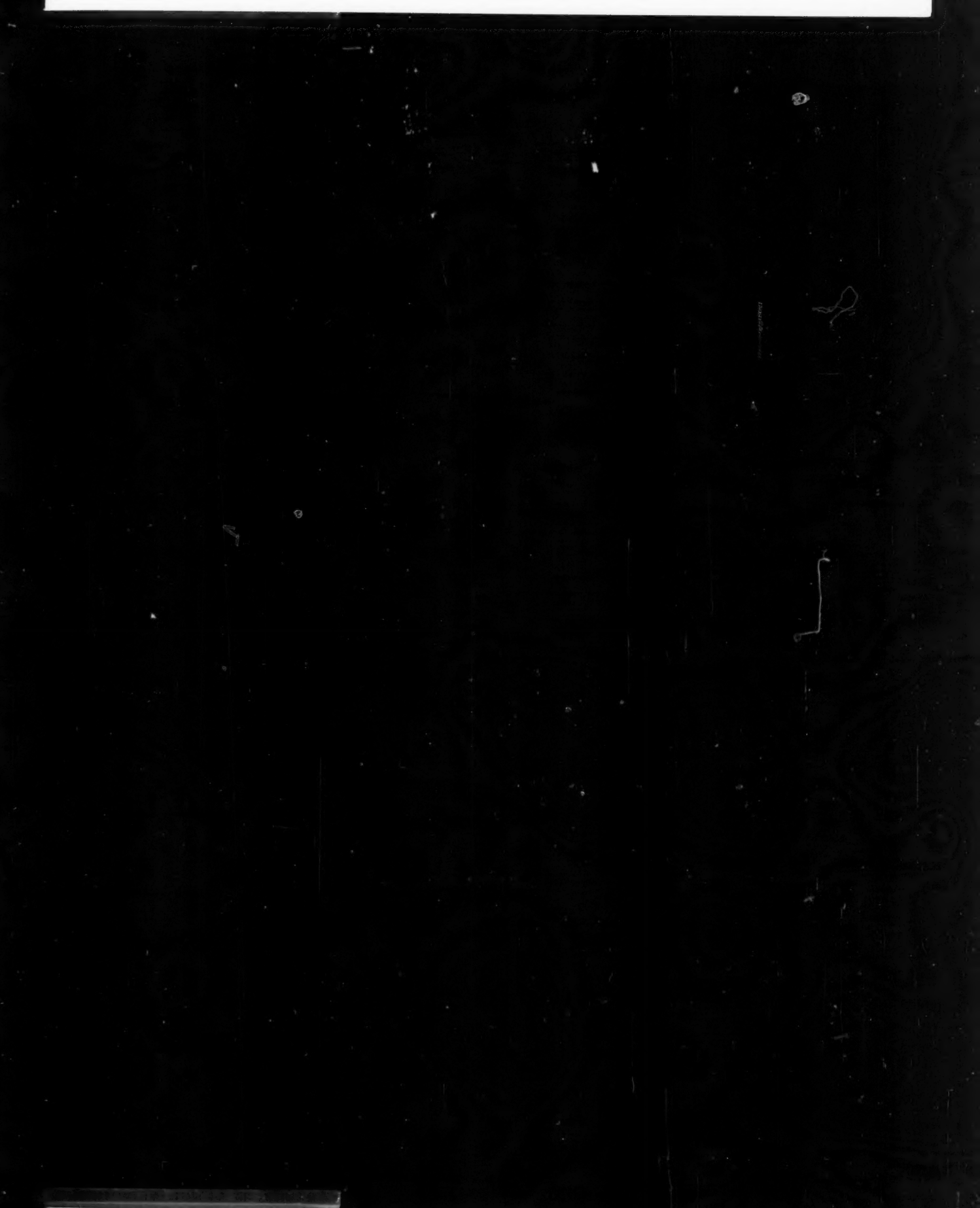
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